Doctoral Thesis

Taxonomic revision of Vietnamese species of the genus *Phintella* Strand (Araneae: Salticidae)

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Summary

Spiders (the order Araneae) are dominant predatory arthropods in terrestrial ecosystems. The family Salticidae (jumping spiders) is the largest family of spiders; it is known throughout the world, and consists of nearly 6,000 described species belonging to 625 genera, holding 13% of all species of spiders (Foelix, 1996; Jackson *et al.,* 2001). Salticids usually show distinct sexual dimorphism in morphology of the adults. As a result, the male-female complementarity remains unclear for many nominal species in this family. This means that more than a few synonymies are likely hidden in the current classification of the family. Furthermore, due to insufficient sampling efforts in tropical and subtropical zones, it is likely that many species are yet to be discovered.

The genus *Phintella* Strand in Bösenberg and Strand (1906) is one of the most speciose genera in the family Salticidae, and is thought to have diversified in the Oriental and Palearctic regions. The species diversity of *Phintella* has been, however, poorly studied in Vietnam, a core area of the Indo-Burma Biodiversity Hotspot (Myers *et al.,* 2000; Sterling *et al.*, 2006). Therfore, the present study aims to revise the classification of Vietnamese species of *Phintella*. Of 61 described species of *Phintella*, the male of 13 described species and the female of 14 described species are unknown. Therefore, a contemporary "Integrated Taxonomy" approach consisting of DNA barcoding, phylogenetic analyses, comparative morphological examination and biogeographical consideration, is applied for confirming the conspecific male-female complementarity.

In the chapter 2, the following taxa were examined by the integrated taxonomy: a total of 129 *Phintella* specimens from Vietnam; three specimens of *Laufeia squamata*; a total of 18 specimens belonging to 15 species of 13 genera (as outgroups). Partitioning with 20–43 MOTUs was proposed by ABGD and PTP analyses based on datasets of mitochondrial CO1 and 16S-ND1, and nuclear 28S genes. Monophyly of each of these MOTUs were then confirmed by Maximum-Likelihood (ML) and Bayesian Inference (BI) phylogenetic trees based on the datasets. If a MOTU were paraphyletic toward other MOTU, those MOTUs should be combined into one MOTU. Consequently, those MOTUs were combined into 15–22. Finally, those 15–22 MOTUs were combined into 22 of which each can be recognized with morphological diagnositic characterisitics of male and *Female genitalia.* Therefore, each of those 22 MOTUs was considered

independent species. Conspecificities of *P. aequipeiforms* Zabka, 1985 and *P. lucai* Zabka, 1985, of *P. debilis* (Thorell, 1891) and *P. bifurcilinea* (Bösenberg & Strand, 1906), and of *P. suavis* (Koch, 1846) and *P. vittata* (Koch, 1846) were confirmed. The male-female complementarity was newly confirmed for 12 species, and the correct male-female complementarity was revealed for *L. squamata*.

In the chapter III, the phylogenetic relationship of Vietnamese *Phintella* species was inferred. The results of Maximum Likelihood and Bayesian phylogenetic analyses based on mtCOI, 16S-ND1 and 28S rDNA indicated that *L. squamata* was nested within a distinct clade involving all of the Vietnamese species of *Phintella* (VN clade). Four clades were also recognized in the VN clade: *P. debilis* clade, *P. lepidus* clade, *P. versicolor* clade and *P. squamata* clade. The *P. lepidus* clade was recognized by compiling the results of phylogenetic analyses based on COI and 28S, but was not recognized by the results of phylogenetic analyses based on 16S-ND1. The position of *P. sancha* is unstable, i.e., nested in the *P. debilis* clade, or sister to a clade consisting of the *P. debilis* clade and the *P. lepidus* clade. In the present study, the *P. lepidus* clade and *P. sancha* are tentatively treated as the two independent clades.

In the chapter 4, the Vietnamese species of *Phintella* were taxonomically revised. The identities of *Phintella accentifera* and *P. argenteola*, which could not be investigated by the present integrated taxonomy approach, were morphologically considered. Conspecificity of *P. argenteola* and *P. debilis* was proposed; and *Phintella accentifera* was recognized as an independent species. A total of 23 species were recognized from Vietnam, with 13 of these being new species. Key to species based on the male and the female and descriptions/redescriptions of the 23 species were provided, and four cases of synonyms were solved.

In the Chapter V, distributional pattern of the 23 *Phintella* species are overviewed. Three species (*P. debilis, P. versicolor* and *P. vittata*) were distributed throughout Vietnam. Two other species (*P. lepidus* and *P. sancha*) were found only from Southern Vietnam in the present study, but are also known from Southern China, thus the two species may be actually widespread in other parts of Vietnam. Ten species were found in the Northern Climatic Regime, and at least some of them are known from southern China. On the other hand, five species were found from the Southern Climatic

Regime, and three species from the transition region between the Northern and Southern Climatic Regimes, i.e., Truong Son Range in Central Vietnam. Although distributional data of *Phintella* spp. in the western part of the Indo-Chinese Peninsula has not yet been accumulated, the present study reveals that species composition of *Phintella* changes drastically between the two climatic regimes.

Interspecific and intraspecific K2P divergences calculated based on the COI dataset highlight a very clear barcode gap: 2.22 % in maximum intraspecific divergence and 4.40 % in minimum interspecific divergence. The results fit very well with these previous results on Canadian spiders and salticids (Blagoev *et al*., 2016). Integrated taxonomy can not be applied to cases where only a small number of specimens is available. Therefore, the "2–5% threshold" should be useful as a "scale" for estimating whether multiple species are present in the small collection or not.

The present study is a model case of the taxonomic revisions dealing with spiders and other terrestrial arthropods which will be highly speciose in the tropics and subtropics.

Contents

Chapter 1.

GENERAL INTRODUCTION

1.1. General introduction of jumping spiders

The order Araneae, the group of invertebrates known as “spiders”, is one of the major groups of predatory arthropods in terrestrial ecosystems (Foelix, 1996), and the global spider community consumes 400–800 million tons of prey per year, approximately 0.1% of the global terrestrial net primary production (Nyffeler & Brikhofer, 2017). Salticidae, a group of spiders called “jumping spiders”, is the most diverse family of Araneae, not only richest in the number of described species (Jackson *et al.*, 2001) but also extraordinary diverse in morphology, behavior, and predatory ecology (Jackson, 1982, 1986; Richman, 1992; Jackson & Pollard, 1996; Hedin & Maddison, 2001). The most distinguishing characteristics of salticids is their well-developed visual acuity, particularly with their large, tubular principal eyes, which are known as anterior medial eyes (Jackson & Pollard, 1996), and in their elaborate vision-mediated predatory behavior, which is more pronounced than in any other spider groups (Hill & Richman, 2009). With such a highly developed visual system, a majority of jumping spiders are diurnal hunters (Richman & Jackson, 1992). While web building spiders lie in their webs erected in the environment and wait for their prey, salticids use sight to gain accurate information about potential prey (Richman & Jackson, 1992). Some salticids (apparently active searchers) spend much of their time walking and stopping periodically to look around. If they come near prey, they actively pursue it. Other species spend more time visually scanning the environment from one place and then stalking prey that come near (Richman & Jackson, 1992).

Salticids are also known to use their visual acuity for mating. Visual displays during courtship act as species-specific stimuli in properly recognizing opposite-sex conspecifics (Richman & Jackson, 1992). Furthermore, many salticids also perform

tactile displays when a male and a female come into contact with each other before mating; the repertoire of these displays is sometimes large and complex (Jackson & Harding, 1982; Richman & Jackson, 1992).

Hill and Richman (2009), in their review on the evolution of Salticidae, proposed that Salticidae was derived in the Late Cretaceous period from one of the other Retrolateral Tibial apophysis (RTA) dionychan clades, which include Philodromidae, Thomisidae, Miturgidae, Anyphaenidae, Gnaphosidae and related groups (Hill & Richman, 2009). Their hypothesis was based on modern cladistic analyses using both molecular and morphological data, but only scant attention was paid to the existence of any supporting palaeontological evidence. On the other hand, on the basis of available palaeontological evidence, Penney (2010) mentioned that the fossil record points towarded a Cenozoic origination, though a Late Cretaceous origination cannot be ruled out entirely.

Salticidae is known throughout the world, consists of nearly 6,000 described species belonging to 625 genera, holding 13% of all species of spiders, and is most speciose in the tropics (Richman, 1982; Bodner & Maddison, 2012; World Spider Catalog, 2017). The classification of Salticidae was very recently revised by Maddison (2015) on the basis of both molecular and morphological data, and the family is divided into seven subfamilies: Onomastinae, Asemoneinae, Eupoinae, Lyssomaninae, Spartaeinae, Hisponinae and Salticinae; among those, the subfamily Salticinae is known throughout the world, including temperate and arctic regions, consists of about 93% of the described species of the family, and is subdivided into two major clades, the Amycoida and the Salticoida. On the other hand, Prószyński (2016b) revised the classification on the basis of the morphology of reproductive organs, i.e., male palps and female genitalia, and proposed 37 “groups of genera”.

Indo-Chinese Peninsula is a biogeographically interesting and important area, because it is thought to have high levels of species diversity and endemism (Sterling *et al.*, 2006; Myers *et al.,* 2000), and it has been a main source area producing new species and providing them to the surrounding areas since Miocine (De Bruyn *et al.*, 2014). Vietnam, located along the eastern coast of the Indo-Chinese Peninsula, is known as a core area of the Indo-Burma Biodiversity Hotspot (Myers *et al.,* 2000; Sterling *et al.*, 2006). However, the species diversity of Salticidae remains largely unknown in Vietnam

and adjacent areas. Zabka (1985) is the only taxonomist who revised Vietnamese salticids and recognized 100 species, including 51 new species. However, his study was conducted completely by traditional morphological approach based on specimens collected mainly from Northern Vietnam and stored in various museums in the world. Few specimens from central and Southern Vietnam were examined. Furthermore, as mentioned in Section 1.3, the complementarity of conspecific male and female is very difficult to clarify by a traditional morphological approach because of the remarkable sexual dimorphism in morphology and coloration. To date, the number of species and genera recorded from Vietnam increased to 121 and 60, respectively (Zabka, 1985; Peng & Li, 2003; Logunov, 2008; Logunov & Marusik, 2014; Logunov & Jäger, 2015; The World Spider Catalog, 2017), but the numbers are almost same as those in Japan (123 species, 48 genera; Prószyński, 2016b) mostly lying in temperate and subtropical zones. This highlights that the total picture of the species diversity of Salticidae has probably not yet been uncovered in Vietnam and adjacent areas.

1.2. Taxonomic history of the genus *Phintella*

The genus *Phintella* was established by Strand in Bösenberg and Strand, 1906, and the type species of this genus was designated by *Phintella typica* Bösenberg and Strand, 1906 which was described based on a female collected from Japan. However, Prószyński (1983), based on his examination on the type specimens of *P. typica* (female) and *Telamonia bifurcilinea* Bösenberg and Strand, 1906 (male) and nontype specimens from Japan, revealed the conspecificity of *P. typica* and *T. bifurcilinea*, treated the latter as the senior synonym of the former, and re-designate "*P. bifurcilinea*" as the type species of the genus.

Spiders of the genus *Phintella* are defined with a combination of the following characteristics (Fig. 1.1): male and female cephalothorax relatively highly raised; male palpal tegulum with retrolateral bump, usually with posterior lobe; embolus of male palp usually short, pointed or furcated; tibia of male palp with one or more apophyses; insemination ducts of female genitalia variable in length, but usually not twisted; spermatheca usually round (Zabka, 2012; Huang *et al.*, 2015). Maddison (2015) placed

the genus *Phintella* in the tribe Chrysillini (Salticinae: Salticoida: Saltafresia) on the basis of both molecular and morphological data.

The genus *Phintella* is one of the most speciose genera, and a total of 61 species have so far been described from the world (World Spider Catalog, 2017). Among them, 26 species were originally described under *Phintella*, and 35 species were transferred to the genus *Phintella* mainly from *Chrysilla* Thorell, 1887; *Cosmophasis* Simon, 1901; *Dexippus* Thorell, 1891; *Euophrys* Koch, 1834; *Heliophanus* Koch, 1833; *Icius* Simon, 1876; *Jotus* Koch, 1881; *Maevia* Koch, 1846; *Plexippus* Koch, 1846; *Telamonia* Thorell, 1887; *Thiania* Koch, 1846; and *Viciria* Thorell, 1877 (World Spider Catalog, 2017). On the other hand, five species originally described under *Phintella* were later transferred to *Telamonia* Thorell, 1887; *Chalcoscirtus*, Bertkau, 1880; *Nandicius*, Prószyński, 2016a; *Chinattus*, Logunov, 1999; and *Chrysilla*, Thorell, 1887.

A total of 48 species of *Phintella* are known in the Oriental and the Palaearctic regions, 10 species in the Afrotropical region, and 3 in the Australian region, but no species has so far been known from the Nearctic and the Neotropical regions (Zabka, 2012; World Spider Catalog, 2017). The species diversity of *Phintella* as well as other salticid genera has been, however, poorly studied in Vietnam, a core area of the Indo-Burma Biodiversity Hotspot as mentioned above. The oldest record of the genus *Phintella* in Vietnam is *P. argenteola* which was described from Phuc Son, Nghe An province by Simon (1903) as *Telamonia argenteola* and was later transferred to *Phintella* by Prószyński (1984). After many years since Simon (1903), Zabka (1985) revised Salticidae fauna of Vietnam, and recorded 10 species of the genus *Phintella* from Vietnam, including 3 new species, *P. aequipeiformis*, *P. lucai* and *P. tibialis*. However, *P. tibialis* was later transferred to *Habrocestoides* by Peng & Xie, 1995, and then transferred to *Chinattus* by Logunov, 1999. Therefore, the following 9 species are known from Vietnam: *P. accentifera* (Simom, 1901b); *P. aequipeiformis* Zabka, 1985; *P. argenteola* (Simon, 1903); *P. bifurcilinea* (Bösenberg and Strand, 1906); *P. debilis* (Thorell, 1891); *P. lucai* Zabka, 1985; *P. suavis* (Simon, 1885); *P. versicolor* (Koch, 1846); and *P. vittata* (Koch, 1846). Only these two previous studies on Vietnamese *Phintella* were conducted and were based on materials collected mainly from Northern Vietnam. Thus, many species of *Phintella* may remain undiscovered in Central and Southern Vietnam.

1.3. Purposes of this thesis

The present study aims to revise Vietnamese species of the genus *Phintella*. This chapter (1: General Introduction) is followed by four chapters. In Chapter 2, Vietnamese species of the genus *Phintella* are delimitated, and the male-female complementarity is confirmed for each delimitated species using integrated taxonomy designed by referring to Puillandre *et al.* (2012), Zhang *et al.* (2013), Kekkonen & Hebert (2014), Leavitt *et al.* (2015), Montagna *et. al.* (2016) and Zhu *et al.* (2017). In Chapter 3, the phylogenetic structure of Vietnamese *Phintella* is analyzed, and the position of "*Laufeia squamata*" is discussed. In Chapter 4, a total of 23 species of the genus *Phintella* recognized from Vietnam including 13 new species are described/redescribed, and a key to Vietnamese species is provided. In Chapter 5 (General Discussion), distribution patterns of Vietnamese *Phintella* are discussed, and the scientific significance and the prospect of this study are presented.

1.4. Summary of the Topology and Climate in Vietnam

Vietnam is located along the eastern coast of the Indo-Chinese Peninsula, and extends for approximately 1,650 km from 8.3˚N to 23.3˚N. The area of the elongated S-shaped territory is approximately 331,000 km^2 (De Queiroz *et al.*, 2013). Mountainous areas lie in the northern and central regions of this country (Sterling *et al.*, 2006), including three main mountainous areas, where most of its biodiversity remains: (1) the Northeastern region; (2) the northwestern complex dominated by the Hoang Lien Range; and (3) the Truong Son (Annamite) Range, a geomorphic unit known for its high level of endemism (Averyanov *et. al.*, 2003; De Queiroz *et al.*, 2013). The Hoang Lien Son Range is the southeastern most extension of the Himalayas, and the Truong Son Range runs along the country's western border with Laos, ending south of Da Lat Plateau in south–central Vietnam (Sterling *et al.*, 2006; De Queiroz *et al.*, 2013). The lowland below an elevation of 20 m consists primarily of the Mekong Delta (40,000 km^2) in the south, the Red River Delta (15,000 km^2) in the north, and a narrow plain runs along much of the coastline (Sterling *et al.*, 2006; De Queiroz *et al.*, 2013).

A variety of local climate regimes in Vietnam can be grouped into two main regional climates: Northern Climate Regime (from Chinese border south to 18˚N – around Deo

Ngang Pass in Ha Tinh province) and Southern Climate Regime (Tay Nguyen Plateau or West Truong Son and Southern Vietnam with Mekong River delta) (Le, 1997). The Northern Climate Regime is known as "monsoon tropical climate with hot summer and cold winter" (Le, 1997). Summer (from May to October) is hot and rainy; the hottest months are June, July and August, when humidity reaches 80–100%; daily day maximum temperature is over 40˚C; winter season (from November to April) is cold and humid; depending on the location, dry periods can vary from zero to six months (Sterling *et al.*, 2006). The Southern Climate Regime is a typical of monsoon tropical climate with summer rains and a dry season. The Mekong Delta is quite hot almost through the year (ca. 26–27˚C in annual mean, varying within 3–4˚C), and is rainy in the summer from May to October, with the heaviest rains occurring in July and August; the dry season varies from two to six months (Nguyen *et al*., 2000, Sterling *et al.*, 2006). The Tay Nguyen Plateau (West Truong Son) is cooler and wetter than the Mekong Delta, and has the dry season lasting for only three months (Sterling *et al.*, 2006). The climate in the Central part (East Truong Son Climate Regime) is the transition between the Northern and Southern Climatic Regimes, but it is characterized well by the driest and hottest summer and highest rainfall in early winter (October and November) (Le, 1997). Detailed information on the climate in Vietnam is provided by Le (1997), Hijmans *et al.* (2004) and Sterling *et al.* (2006).

References

Averyanov L. V., Phan K. L, Nguyen T. H, Harder D. K. 2003. Phytogeographic review of Vietnam and adjacent areas of Eastern Indochina. Saint Petersburg, Russia. Komarovia 3: 1–83.

Bertkau P. 1880. Verzeichniss der bisher bei Bonn beobachteten Spinnen. Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande und Westfalens 37: 215–343.

Bodner M. R. & Maddison W. P. 2012. The biogeography and age of salticid spider radiations (Araneae: Salticidae). Molecular Phylogenetics and Evolution 65: 213–240.

Bösenberg W., Strand E. 1906. Japanische Spinnen. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 30: 93–422.

De Bruyn M., Stelbrink B., Morley R. J., Hall R., Carvalho G. R., Cannon C. H. & Maiorano L. 2014. Borneo and Indochina are major evolutionary hotspots for Southeast Asian biodiversity. Systematic Biology 63(6): 879–901.

De Queiroz J. S., Griswold D., Nguyen D. T., & Hall P. 2013. Vietnam tropical forest and biodiversity assessment. USAID Vietnam 79 pp.

Foelix R. F. 1996. Biology of spiders. Oxford: Oxford University Press. 330 pp.

Hedin M. C., & Maddison W. P. 2001. A combined molecular approach to phylogeny of the jumping spider subfamily Dendryphantinae (Araneae: Salticidae). Molecular Phylogenetics and Evolution, 18(3): 386–403.

Hijmans R. J., Cameron, S., & Parra, J. 2004. WorldClim, version 1.2. A square kilometer resolution database of global terrestrial surface climate. URL: http://biogeo. berkeley. edu.

Hill D. E. and Richman D. B. 2009. The evolution of jumping spiders (Araneae: Salticidae): a review. Peckhamia 75(1): 1–7.

Huang Y., Wang C. & Peng X. J. 2015. Five new species of *Phintella* Strand, 1906 (Araneae, Salticidae) from the Wuling Mountains, China. Zookeys 514: 25–42.

Jackson R. R., & Harding D. P. 1982. Intraspecific interactions of *Holoplatys* sp. indet., a New Zealand jumping spider (Araneae: Salticidae). New Zealand journal of zoology 9(4): 487–510.

Jackson R. R. 1986. Web building, predatory versatility, and the evolution of the Salticidae. Spiders: Webs, Behavior, and Evolution 232–268.

Jackson R. R., and Pollard S. D. 1996. Predatory behavior of jumping spiders. Annual Review of Entomology 41: 287–308.

Jackson, R. R., Pollard, S. D., Nelson, X. J., Edwards, G. B., & Barrion, A. T. 2001. Jumping spiders (Araneae: Salticidae) that feed on nectar. Journal of Zoology 255(1): 25–29.

Koch C. L. 1833. Arachniden. In: Herrich–Schäffer, G. A. W. (ed.) Deutschlands Insecten, Heft 119–121.

Koch C. L. 1834. Arachniden. In: Herrich–Schäffer, G. A. W. (ed.) Deutschlands Insecten, Heft 122–127.

Koch C. L. 1846. Die Arachniden. Nürnberg, Dreizehnter Band, pp. 1–234, Vierzehnter Band, pp. 1–88.

Koch L. 1881. Die Arachniden Australiens. Nürnberg 1: 1213–1271.

Le B. T. 1997. Viet Nam: the country and its geographical regions. The Gioi Publ..

Logunov D. V. 1999. Redefinition of the genus Habrocestoides Prószyński, 1992, with establishment of a new genus, *Chinattus* gen n. (Araneae: Salticidae). Bulletin of the British Arachnological Society 11: 139–149.

Logunov D. V. 2008. A new species of the genus *Stenaelurillus* Simon 1885 (Araneae: Salticidae) from Vietnam // Acta Arachnologica 57: 43–45.

Logunov D. V., & Marusik Y. M. 2014. Taxonomic notes on the genus *Eupoa* Żabka, 1985 (Arachnida, Araneae, Salticidae). ZooKeys 410: 63.

Logunov D. V. & Jäger P. 2015. Spiders from Vietnam (Arachnida: Aranei): new species and records. Russian Entomological Journal 24(4): 343–363.

Maddison W. P. 2015. A phylogenetic classification of jumping spiders (Araneae: Salticidae). Journal of Arachnology 43(3): 231–292.

Myers N., Mittermeier R. A., Mittermeier C. G., Da Fonseca G. A., & Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403(6772): 853–858.

Nguyen T. H., Phan K. L., & Nguyen T. H. 2000. Bioclimatic diagrams of Vietnam. Vietnam National University Publishing House.

Nyffeler M., & Birkhofer K. 2017. An estimated 400–800 million tons of prey are annually killed by the global spider community. The Science of Nature 104(3–4): 30.

Peng X. J. & Xie L. P. 1995. Spiders of the genus *Habrocestoides* from China (Araneae: Salticidae). Bulletin of the British Arachnological Society 10: 57–64.

Peng X., & Li S. 2003. New localities and one new species of jumping spiders (Araneae: Salticidae) from northern Vietnam. Raffles Bulletin of Zoology 51(1): 21–24.

Penney D. 2010. The evolution of jumping spiders (Araneae: Salticidae): the palaeontological evidence. Peckhamia 81(8): 1–3.

Prószyński J. 1983. redescriptions of *Phintella typica* and *Telamonia bifurcilinea* (Araneae: Salticidae). Acta arachnologica 32(1): 5–14.

Prószyński J. 1984. Atlas rysunków diagnostycznych mniej znanych Salticidae (Araneae). Wyższa Szkola Rolniczo–Pedagogiczna, Siedlcach 2: 1–177.

Prószyński J. 2016a. Delimitation and description of 19 new genera, a subgenus and a species of Salticidae (Araneae) of the world. Ecologica Montenegrina 7: 4–32.

Prószyński J. 2016. Monograph of the Salticidae (Araneae) of the world 1995–2015. Version October 304th, 2016. Available online at: http://peckhamia.com/salticidae/.

Richman D. B. 1982. Epigamic display in jumping spiders (Araneae, Salticidae) and its use in systematics. Journal of arachnology, 47–67.

Richman D. B., & Jackson R. R. 1992. A review of the ethology of jumping spiders (Araneae, Salticidae). Bulletin of the British Arachnological Society 9(2): 33–37.

Simon E. 1876. Les arachnides de France. Tome troisième. Roret, Paris, 364 pp., pl. IX–XIII.

Simon E. 1885. Matériaux pour servir à la faune arachnologiques de l'Asie méridionale. *Bulletin de la Société Zoologique de France* 10: 436–462.

Simon E. 1901. Histoire naturelle des araignées. Paris 2: 381–668.

Simon E. 1903. Etudes arachnologiques. 33e Mémoire. LIII. Arachnides recueillis à Phuc-Son (Annam) par M. H. Fruhstorfer (nov–dec. 1899). Annales de la Société Entomologique de France 71: 725–736.

Sterling E. J, Hurley. M. M & Le M. D. 2006. Vietnam: a national history. Yale University Press. New Haven and London. 444 pp.

Thorell T. 1887. Viaggio di L. Fea in Birmania e regioni vicine. II. Primo saggio sui ragni birmani. Annali del Museo Civico di Storia Naturale di Genova 25: 5–417.

Thorell T. 1891. Spindlar fran Nikobarerna och andra delar af Sodr a Asien till storre delen insamlade under K. Danska Korvetten Galatheas resa omkring jorden aren 1845–1847. Bihang till Kongl. Svenska vetenskaps-akademiens handlingar 24(2): 1–149.

World Spider Catalog 2017. World Spider Catalog. Natural History Museum Bern. Available at http://wsc.nmbe.ch, version 17.5 (accessed 2017).

Zabka M. 1985. Systematic and zoogeographic study on the family Salticidae (Araneae) from Vietnam. Annales Zoologici Warszawa 11: 1–485.

Zabka M. 2012. *Phlegra* Simon, 1876, *Phintella* Strand 1906 and *Yamangalea* Maddison, 2009 (Arachnida: Araneae: Salticidae) – new species and new generic records for Australia. *Zootaxa* 3176: 61–68.

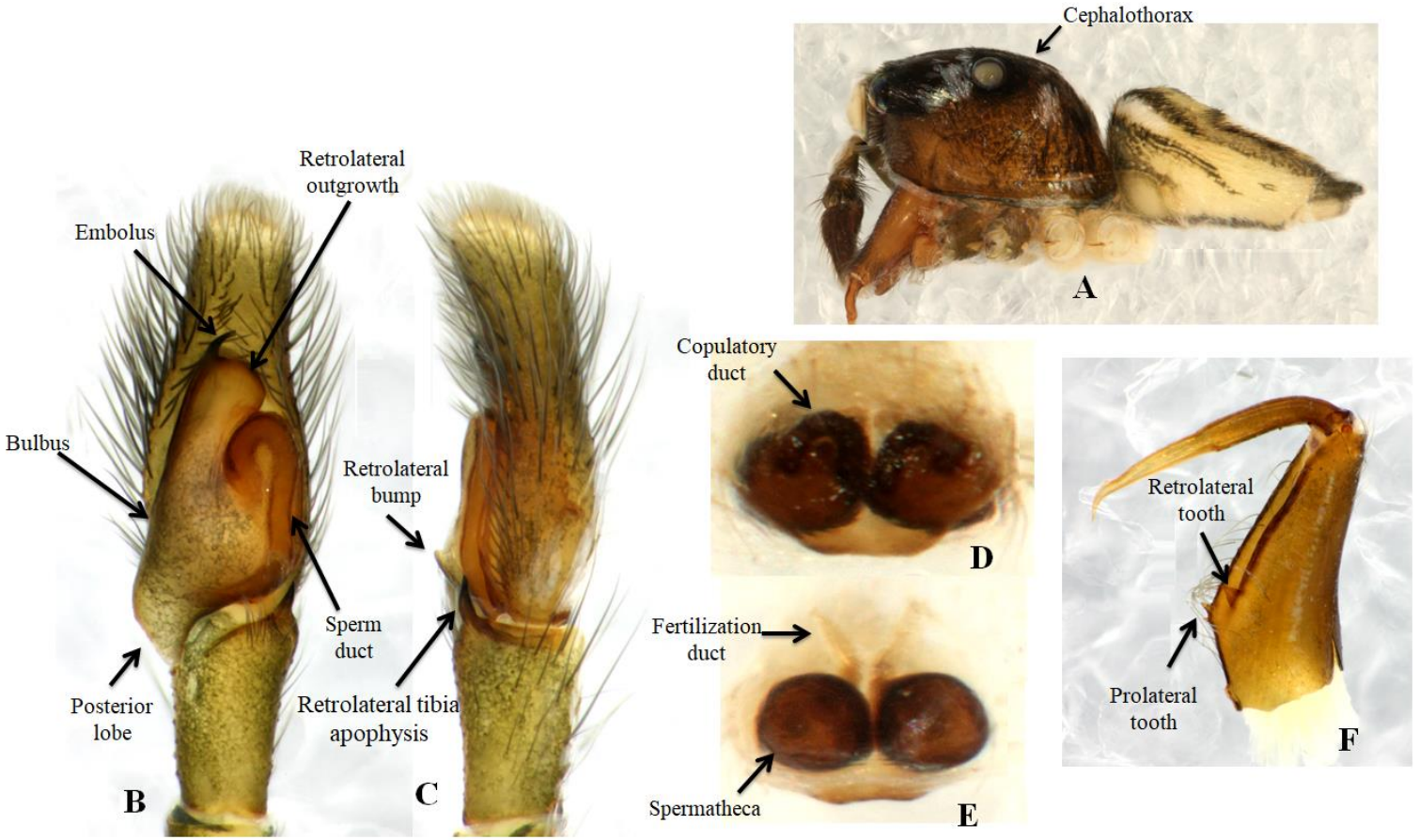

Figure 1.1. Morphological terms used for the genus *Phintella*. (A) Body, male, lateral view. (B) Palp, male, ventral view. (C) Palp, male, retrolateral view. (D) Genitalia, female, ventral view. (E) Genitalia, female, dorsal view. (F) Chelicera and fang, male, retrolateral view.

Chapter 2.

DELIMITATION OF VIETNAMESE SPECIES OF THE GENUS *PHINTELLA*

2.1. Introduction

2.1.1. Sexual dimorphism

"Sexual dimorphism" means that the two sexes of a species differ in external appearance or other features (Ralls & Mesnick, 2002). Darwin (1871) considered that most sexual dimorphism was due to sexual selection, in which evolutionary forces act differently on the sexes (Ralls & Mesnick, 2002). Although Darwin's ideas about sexual selection have stood the test of time, some cases of sexual dimorphism seem to be best explained by natural selection (Ralls, 1976; Andersson, 1994; Ralls & Mesnick, 2002). The emerging view is that the degree of sexual dimorphism in a species is the result of the difference between the sum of all the selective pressures (natural selection and sexual selection) affecting the male and the sum of those affecting the female (Ralls & Mesnick, 2002).

2.1.2. Species delimitation and integrated taxonomy

Although species serve as basic and useful units for recognizing and classifying biological diversity. A majority of modern taxonomists, as well as other biologists, accept the "Biological species concept" (Mayr, 1942), while, in practice, taxonomists had recognized species mostly or completely based on morphological characteristics until recently. However, polymorphism in a single species, e.g., sexual dimorphism and polymorphism seen among different developmental stages, is known in various taxa, and this brings difficulties in recognizing species by traditional comparative morphological examination.

DNA barcoding is a method to identify unknown samples by comparing its sequences of standardized gene markers, such as the "Folmer Region" of the mitochondrial CO1

gene, with existing libraries of sequences of identified species (Hebert *et al.*, 2003). In recent years, DNA barcoding has been increasingly used in taxonomic studies as well as specimen identifications of various taxa (Hebert *et al.*, 2003; Bickford *et al.*, 2006; Fisher & Smith, 2008; Ferri *et al.*, 2009; Robinson *et al.*, 2009; Pires & Marinoni, 2010; Zhu *et al.*, 2017). It is especially powerful for revealing male-female complementarity, and subsequently solving synonymies and/or unifying the male-based and female-based classifications (Barrett & Hebert, 2005; Robinson *et al.*, 2009; Ekrem *et al.*, 2010; Tanikawa, 2011; Glowska *et al.*, 2014; Phung *et al.*; 2016).

Very recently, "Integrated Taxonomy" (Ferri, 2009; Montagna, 2016) has been widely used by taxonomists for renewing species-level classification in various animal taxa (Ferri, 2009; Marcos-García *et al*., 2011; Hoisington-Lopez *et al*., 2012; Diaz *et al.*, 2015; Montagna, 2016). In practice, it is difficult for taxonomists to directly observe the presence/absence of reproductive isolation, i.e., the criterion of "biological species" (Mayr, 1942), among multiple species in natural and laboratory conditions. Therefore, integrated taxonomy provides one alternative. It aims to delimitate species by referring multiple indirect evidences obtained from traditional comparative morphological examination, DNA barcoding, phylogenetic analyses, and, if necessary, other modern analyses, e.g., karyotyping, cuticular hydrocarbon analysis and quantitative morphometry.

2.1.3. Taxonomic problem of the salticid genus **Phintella**

The family Salticidae, the so-called "jumping spiders", is the most diverse family of Araneae, not only richest in the number of described species (Jackson *et al.*, 2001) but also extraordinary diverse in morphology, behavior, and predatory ecology (Jackson, 1982, 1986; Richman, 1992; Jackson & Pollard, 1996; Hedin & Maddison, 2001). Salticidae are found throughout the world, but is most speciose in the tropics (Richman, 1982), and consists of nearly 6,000 described species belonging to 625 genera, holding 13% of all species of spiders (Bodner & Maddison, 2012; World Spider Catalog, 2017).

The genus *Phintella* is one of the most speciose genera in the Salticidae, and 61 species have so far been described from the world (World Spider Catalog, 2017), and is very speciose mainly in the continental Asian tropics: 35 species in the Oriental, 18 in Palaearctic regions combined; 10 species in the Afrotropical region, and 3 in the

Australian region, but no species has so far been described/recorded from the Nearctic and the Neotropical regions (Zabka, 2012; World Spider Catalog, 2017).

Indo-Chinese Peninsula is a biogeographically interesting and important area, because it is thought to have high levels of species diversity and endemism (Sterling *et al.*, 2006; Myers *et al.,* 2000), and it has been a main source area producing new species and providing them to the surrounding areas since Miocine (De Bruyn *et al.*, 2014). Vietnam, located along the eastern coast of the Indo-Chinese Peninsula, is known as a core area of the Indo-Burma Biodiversity Hotspot (Myers *et al.,* 2000; Sterling *et al.*, 2006). However, the species diversity of Salticidae remains largely unknown in Vietnam and adjacent areas.

The oldest record of the genus *Phintella* in Vietnam is *P. argenteola*. The species was described from Phuc Son, Nghe An province by Simon (1903) as *Telamonia argenteola*, and was later transferred to *Phintella* by Prószyński (1984). After many years since Simon (1903), Zabka (1985) revised Salticidae fauna of Vietnam and recorded 10 species of *Phintella* from Vietnam, including three new species, *P. aequipeiformis*, *P. lucai* and *P. tibialis*. However, *P. tibialis* was later transferred to *Habrocestoides* by Peng & Xie, 1995, and then transferred to *Chinattus* by Logunov, 1999. Therefore, the following 9 species are known from Vietnam: *P. accentifera* (Simom, 1901); *P. aequipeiformis* Zabka, 1985; *P. argenteola* (Simon, 1903); *P. bifurcilinea* (Bösenberg and Strand, 1906); *P. debilis* (Thorell, 1891); *P. lucai* Zabka, 1985; *P. suavis* (Simon, 1885); *P. versicolor* (Koch, 1846); and *P. vittata* (Koch, 1846). These two previous studies on Vietnamese *Phintella* were based on material collected mainly from Northern Vietnam. Thus, not a few species of *Phintella* are likely to remain undiscovered in Central and Southern Vietnam.

The majority of the species of *Phintella* as well as other salticid genera show distinct sexual dimorphism in adult morphology, e.g., the coloration of the body, and the shape of the first pair of legs and chelicerae. Remarkable coloration and morphology in the males have functions primarily in visually attracting conspecific females (Packham & Peckham, 1889, 1890; Crane, 1949; Richman, 1982). Therefore it is difficult or impossible in proposing the conspecific male-female complementarity by traditional morphological approach. As the result, nearly a half of described species of *Phintella*

have so far been known from one sex, i.e., the male of 13 described species and the female of 14 described species is unknown (World Spider Catalog, 2017). This means that more than a few synonymies are likely hidden in the current classification of the genus *Phintella*.

2.1.4. Purpose of this chapter

The present study aims to deliminate species of *Phintella* collected from Vietnam using a contemporary "Integrated Taxonomy" approach consisting of DNA barcoding, phylogenetic analyses, comparative morphological examination and biogeographical consideration. This is an ideal tool for revealing the male-female complementarity for each species and solving synonymies in *Phintella*.

2.2. Materials and methods

2.2.1. Taxon sampling

Specimens of Salticidae were newly collected in various localities of Vietnam, and a total of 260 adult specimens were identified as the genus *Phintella* by referring to Zabka (1985, 2012) and Cao & Li (2016); 18 "*Phintella*-like" adult specimens were also treated as *Phintella*. The *Phintella* specimens were then roughly sorted into 36 morphospecies; male-female complementarity was ignored in this preliminary sorting. In the case where a morphospecies contains a few numbers of specimens, all specimens were used for the following integrated taxonomy. On the other hand, in the case where a morphospecies contained dozens of specimens, some of them were chosen by considering the geographic range of the morphospecies. Finally, a total 129 adult specimens were examined (Table 2.1). In addition, three adult females of *Laufeia squamata* (Zabka, 1985) were included as ingroups because the females found in Vietnam and expected to be this species were morphologically similar to those of some Vietnamese *Phintella* (Table 2.1).

A total of 18 adult specimens belonging to 15 species of 13 genera were examined as outgroups. Four of them, *Cosmophasis* sp., *Menemerus bivitattus* (Dufour, 1831), *Siler severus* (Simon, 1901b) and *Telamonia festiva* (Thorell, 1887), were newly collected from Vietnam; *Chrysilla lauta* Thorell, 1887 from Thailand (Table 2). The sequences of

the remainder were obtained from Genbank (https://www.ncbi.nlm.nih.gov/): *Carrhotus xanthogramma* (Accession No. NC027492.1), *Carrhotus* sp. (KY017322.1), *Cosmophasis micerioides* (Accession No. EU815580.1), *Habronattus oregonenesis* (AY571145.1), *Heliophanus cupreus* (DQ665756.1 (COI) and EF201653.1 (28S)), *Nungia epigynalis* (KM033192.1), *Pancorius* sp. (JX145780.1), *Plexippus paykulli* (NC024877.1), *Salticus scenicus* (KY017355.1), and *Thiania bhamoensis* (X145761.1).

2.2.2. DNA extraction, PCR amplification and sequencing

Genomic DNA was extracted from leg III or IV of the right side of each spider. The leg from each spider was transferred into a 1.5 mL microcentrifuge tube with 105 μL of extraction buffer (a mixture of 100 μL of 10% Chelex-TE solution and 5 μL Qiagen Proteinase K), incubated at 56˚C for about 24 hours, and then heated at 99˚C for 10 minutes for inactivating the Qiagen Proteinase K.

Three gene regions were amplified and sequenced: CO1 (928-bp of the mitochondrial cytochrome oxidase I), 16S-ND1 (699-bp region spanning the middle of ribosomal RNA 16S to the middles of NADH dehydrogenase subunit I, with an intervening $tRNA^{LEU(CUN)}$), and 28S (821-bp of the nuclear-encoded large subunit (28S) ribosomal repeat). The COI region is commonly used for species delimitation in various animal taxa (Hebert *et al.*, 2003; Bickford *et al.*, 2006; Fisher & Smith, 2008; Ferri *et al.*, 2009; Robinson *et al.*, 2009; Pires & Marinoni, 2010; Puillandre *et al.*, 2012; Zhang *et al.*, 2013; Kekkonen & Hebert, 2014, Montagna *et. al.*, 2016 and Zhu *et al.*, 2017); the COI, 16S-ND1 and 28S are commonly used for molecular phylogenetic analyses in Salticidae (Hedin & Maddison, 2001; Maddison & Hedin, 2003; Maddison *et al*., 2007; Madditson *et al*., 2008; Bodner & Maddison, 2012; Maddison & Li, 2014). Primer sets were given in Table 2.2.

Each polymerase chain reaction (PCR) contained 5 μL of 2xPCR buffer, 2 μL of dNTPs (final 0.4 mM), 0.3 μL of 10 pmol/μL forward and reverse primers (final 0.3 μM), 0.2 μL of 1.0 U/μL DNA polymerase KOD FX Neo (TOYOBO KFX-2015), and 0.5 μL of DNA template. The PCR conditions to amplify COI, 16S-ND1 and 28S were as follows: initial denaturation at 94°C for 2 min; 35 cycles of 10 sec at 98°C, 30 sec at either 44°C (16S-ND1) or 52°C (COI) or 55°C (28S), and 45 sec or 1 min at 68°C; and a final cycle of 7 min at 68°C. After confirming the PCR amplification on a 2.0% agarose gel, the

amplified products were incubated at 37°C for 30 min and at 80°C for 20 min with an Illustra^{TM} ExoStar (GE Healthcare, Buckinghamshire, UK) to remove any excess primers and nucleotides. The cycle sequencing reactions were run with an ABI PRISM BigDye Terminator Cycle Sequencing Kit v.3.1 (Applied Biosystems). The sequencing reaction products were purified, concentrated by ethanol precipitation with sodium acetate, and their nucleotide sequences were determined using an automated sequencer (ABI PRISM 3100, Applied Biosystems). Forward and Reverse strands were assembled after trimming the primer regions and disarrayed parts, and questionable sites were manually confirmed by referring to the chromatograms of the two strands. This process was done using ChromasPro 2.1.5 (Technelysium Pty Ltd., Australia).

2.2.3. Sequence alignment

These sequences were aligned using Muscle (Edgar, 2004) built in MEGA 6.06 (Tamura *et al.*, 2013) by setting parameters as default. For the further calculations and analyses, all sequence positions containing gaps were eliminated. In total, 210 sequence alignments (109 of COI, 50 of 16S-ND1 and 51 of 28S) from 132 specimens of Vietnamese *Phintella*, *Phintella*–like species, and *Laufeia squamata* were used as input for species delimitation analyses.

2.2.4. Phylogenetic analyses

Maximum likelihood (ML) and Bayesian inference (BI) analyses were performed for each individual gene region (COI, 16S-ND1 and 28S). Nucleotide substitution models for the three molecular markers were determined in kakusan4 version 4.0 (Tanabe 2011; https://www.fifthdimension.jp/products/kakusan/). The protein coding region (COI) was partitioned by codon positions.

In the ML analysis, the following substitution models were chosen based on the AICc (Sugiura 1978): HKY85_Gamma for the COI dataset, and GTR_Gamma for the 16S-ND1 and 28S datasets. ML trees were created using Treefinder version March 2011 (http://www.treefinder.de/); bootstrap probabilities were calculated from 1000 resamplings.

In the BI analysis, GTR_Gamma model was chosen for all datasets based on the Bayesian information criterion (BIC) (Schwarz 1978). BI analysis was then performed using MrBayes version 3.1.2 (Ronquist and Huelsenbeck 2003). This analysis was

conducted with two independent runs. Four chains were run for 1,000,000 generations each, and sampled every 500 generations. The first 25% of trees were discarded as burn–in. The BI tree from the result was displayed by using Figtree version 1.4.3 (http://tree.bio.ed.ac.uk/software/figtree/).

2.2.5. DNA barcoding analyses

Automatic Barcode Gap Discovery (ABGD; Puillandre *et al.*, 2012) and Bayesian implementation of the Poisson Tree Processes model (bPTP; Zhang *et al.*, 2013) were used for delimitating MOTUs (molecular operational taxonomic units).

ABGD analysis applies a clustering algorithm to distinguish partitions in the genetic distances among a group of individuals, using a two-phased procedure to create a final array of MOTUs (Puillandre *et al.*, 2012; Kekkonen and Hebert, 2014). The first round of ABGD analyses were performed for the CO1, 16S-ND1 and 28S dataset (FASTA files produced by Mega 6.06, as mentioned above) at the web interface (http://wwwabi.snv.jussieu.fr/public/abgd/; web version 'May 31, 2017'), by setting the relative gap width and the other parameters as default (Pmin: 0.001; Pmax: 0.1; Steps: 10; X: 1.5; Nb bins: 20), and selecting all of the three substitution models, i.e., JC69, K2P and P-distance. Because the first round found just a single group for the three datasets (excluding the sequences of outgroups) under the three substitution models, a second round was performed by setting the relative gap width to 1.0 (but setting other parameters as default).

The Poisson tree processes (PTP) model infers putative species boundaries on a given phylogenetic input tree (Zhang *et al.*, 2013). The bPTP is an updated version of the original maximum likelihood PTP, with Bayesian support (BS) values to delimited species on the input tree. Higher BS value on a node indicates all descendants from this node are more likely to be from one species. bPTP analyses were performed at the web interface (http://species.h-its.org/ptp/); parameter values employed defaults.

2.2.6. Morphological examination

Specimens of which leg(s) used for DNA extraction were morphologically examined under an Olympus SZX12 microscope. Multifocused montage images of the body and male palp were produced using Helicon 6.2.2 Pro from a series of source images taken by Canon EOS X5 cameras attached to a Nikon SMZ1270 microscope, and by

Panasonic Lumix DMC-GX8 cameras attached to a Nikon AZ100 microscope. Female genitalia was detached, and cleared by soaking them in 10% KOH solution at room temperature for about 24 hours. Multi-focused montage images of the genitalia were then produced using Helicon 6.2.2 Pro from a series of source images taken by a Canon EOS X5 camera attached to Nikon Eclipse E600 microscope, and by a Panasonic Lumix DMC-GX8 camera attached to a Nikon AZ100 microscope.

The following type materials were examined for identifying the species recognized by integrated taxonomy:

Phintella accentifera (Simon, 1901). Lectotype (male); locality: Kodaikanal, India; depository: Muséum national d'Histoire naturelle (MNHN). Paralectotypes (10 males, 22 females, 7 juveniles); Kodaikanal, India; MNHN.

Phintella argenteola (Simon, 1903). Holotype (male); Nghe An province, Vietnam; MNHN.

Phintella aequipeiformis (Zabka, 1985). Holotype (male); Lao Cai province, Vietnam; Hungarian Natural History Museum (HNHM).

Phintella lucai (Zabka, 1985). Holotype (female); Yen Bai province, Vietnam; HNHM.

Phintella suavis (Simon, 1885). Holotype (male); Malacca, Malaysia; MNHM.

Phintella vittata (Koch, 1846). Holotype (female); Bintang, Indonesia; Museum für Naturkunde Berlin (ZMB).

2.2.7. Integrated taxonomy

The integrated taxonomy analysis in the present study (Fig. 2.1) was designed by referring to Puillandre *et al.* (2012), Zhang *et al.* (2013), Kekkonen & Hebert (2014), Leavitt *et al.* (2015), Montagna *et. al.* (2016) and Zhu *et al.* (2017).

Step 1: MOTU-partitioning. MOTUs were deliminated by ABGD and bPTP analyses based on CO1, 16S-ND1 and 28S datasets. The partitionings with the highest MOTU count proposed by ABGD under three substitution models, i.e., JC69 (ABGD-JC69), K2P (ABGD-K2P) and P-distance (ABGD-P), bPTP with Bayesian supported solution

(bPTP-BS) and bPTP with Maximum likelihood solution (bPTP-ML) were selected as working hypotheses for the evaluations by phylogenetical criterion.

Step 2: Phylogenetic Criterion. The monophyly of each MOTU was evaluated by molecular phylogenetic analyses based on CO1, 16S-ND1 and 28S. A MOTU was confirmed to be monophyletic when the maximum likelihood bootstrap value and Bayesian posterior probability value are ≥ 70 and ≥ 0.90, respectiely. If a MOTU was paraphyletic toward other MOTU(s), those were combined and treated as one MOTU.

Step 3: Morphological Criterion. Each MOTU supported in step 2 was compared with the phylogenetically closest MOTU(s) based on morphology, especially structures of reproductive organs, i.e., male palp and *Female genitalia.* If morphologically undistinguishable, those MOTUs were combined into a single putative species with multiple "genetically distinct groups". On the other hand, if morphologically distinguishable, each of those MOTUs was treated as an independent putative species (but see in step 4).

Step 4: Biogeographical Criterion. If a MOTU was represented by specimens from a few localities, and allopatric from phylogenetically closest MOTU(s), those MOTUs were considered to be combined into one putative species on the conservative presumption that the observed divergences of sequences and morphology apparent between them reflect phylogeographic variation in a single species

2.2.8. Intra- and interspecific divergences

Intraspecific and interspecific divergences were calculated using the K2P models in MEGA 6.06.

2.3. Results

2.3.1. MOTUs deliminated by ABGD and bPTP analyses

The COI gene fragment sequence (928-bp) was obtained from 112 of the 132 ingroup specimens (Table 2.1). Based on this dataset, 20 to 43 MOTUs were delimitated by ABGD analyses under three substitution models (JC69, K2P and p-distance), 26 MOTUs by bPTP-BS, and 24 MOTUs by bPTP-ML (Table 2.3, 2.4). Therefore, the partitionings with the highest MOTU count, i.e., 43 in ABGD-JC69, 26 in bPTP-BS,

and 24 in bPTP in bPTP-ML, were selected as working hypotheses for evaluation by phylogenetical criterion (Table 2.4; Fig. 2.2).

The 16S-ND1 gene fragment sequence (699-bp) was obtained from 52 of the 132 ingroup specimens. Based on this dataset, 16 to 20 MOTUs were delimitated by ABGD analyses under three substitution models (JC69, K2P and p-distance), 20 MOTUs by bPTP-BS, and 20 MOTUs by bPTP-ML (Table 2.3, 2.5). Therefore, the partitionings with the highest MOTU count, i.e., 20 in ABGD-JC69, 20 in bPTP-BS, and 20 in bPTP in bPTP-ML, were selected as working hypotheses for evaluation by phylogenetical criterion (Table 2.5; Fig. 2.3).

The 28S gene fragment sequence (821-bp) was obtained from 51 of the 132 ingroup specimens. Based on this dataset, 4 to 22 MOTUs were delimitated by ABGD analyses under three substitution models (JC69, K2P and p-distance), 17 MOTUs by bPTP-BS, and 15 MOTUs by bPTP-ML (Table 2.3, 2.6). Therefore, the partitionings with the highest MOTU count, i.e., 22 in ABGD-JC69, 17 in bPTP-BS, and 15 in bPTP in bPTP-ML, were selected as working hypotheses for evaluation by phylogenetical criterion (Table 2.6; Fig. 2.4).

2.3.2. Evaluation by phylogenetic criterion

A total of 20 MOTUs (C1–C20) were recognized by phylogenetic criterion based on COI dataset (Table 2.4; Fig. 2.2); 20 MOTUs (SN1–SN20) were recognized based on 16S-ND1 dataset (Table 2.5; Fig. 2.3); and 15 MOTUs (S1–S15) were recognized based on 28S dataset (Table 2.6; Fig. 2.4). Compatibility among the three partitionings was high.

2.3.3. Evaluation by morphology and biogeographical criteria

The COI-based partitioning with 20 MOTUs and 16S-ND1-based partitioning with 20 MOTUs were almost completely supported by morphological criterion (Table 2.7; Figs. 2.2–2.4). Finally, the 22 MOTUs were here treated as independent putative species (Table 2.7). There was no MOTU which needed to be considered with the biogeographical criterion.

2.4. Discussion

2.4.1. Status of each putative species recognized by the present integrated taxonomy

The identity of each of the 22 putative species recognized by the present integrated taxonomy approach is separately discussed as below by referring to the type materials and/or to the original descriptions of the species known from Indo-China and adjacent areas, and other taxonomic references (Koch, 1846; Simon, 1885; Thorell, 1891; Bösenberg & Strand, 1906; Zabka, 1985; Schenkel, 1963; Xie, 1993; Peng *et al.*, 1993; Song *et al.*, 1999; Yin *et al.*, 2012; Zabka, 2012; Prószyński, 2014; Cao & Li, 2016).

Subsequentaly, a total of 22 species, including 13 undescribed species, were recognized by the present integrated taxonomy method (after transferring "*Laufeia squamata*" to *Phintella* as discussed below). This means the number of *Phintella* species known from Vietnam increased by more than double from nine species at the beginning of the present study. Furtheremore, the male-female complementarity was Re-confirmed for 4 species and newly confirmed for 12 species, and was corrected for "*Laufeia squamata*".

***Phintella aequipeiformis* Zabka, 1985**

Monophyly: C1 in COI (bootstrap value = 100, posterior probability = 1), SN1 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), S1 in 28S (bootstrap value = 100, posterior probability = 1).

Identification: The male and the female of this putative species were identified as *P. aequipeiformis* Zabka, 1985 and *P. lucai* Zabka, 1985, respectively. The former was described based on a male collected from northern Vietnam, and the latter based on a female also from northern Vietnam, and the conspecificity of the two nominal species was proposed by Phung *et al.* (2016). Integrated taxonomy in the present study reconfirmed their treatment.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. cavaleriei* and *P.* sp. 2 by dorsum of abdomen in both sexes with one white and two black transversal bands of setae; spermatheca divided into relatively small anterior and large posterior parts by a weak constriction; and copulatory duct connected to middle part of spermatheca.

***Phintella debilis* (Thorell, 1891)**

Monophyly: C2 in COI (bootstrap value = 97, posterior probability = 1), SN2+SN3 in 16S-ND1 (bootstrap value = 100, posterior probability = 1); paraphyletic in 28S (part of S2).

Identification: The male and the female of this putative species were identified as *P. debilis* (Thorell, 1891) and *P. bifurcilinea* (Bösenberg & Strand, 1906), respectively. Although, the two "forms" are distinguishable from each other by the shape of anterior part of bulbus and embolus in male palp, body color pattern in both sexes and female genitalia are similar between the two nominal species. The conspecificity of the two nominal species was supported by the present integrated taxonomy. The formal taxonomic treatment will be done in the Chapter 4.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. monteithi* by dorsum of male carapace with six to seven white patches of setae; and copulatory duct connected to anterior part of spermatheca

***Phintella monteithi* Zabka, 2012**

MOTU recognition: C4 in COI (bootstrap value = 99, posterior probability = 1), SN4 in 16S-ND1 (bootstrap value = 99, posterior probability = 1), paraphyletic in 28S (part of S2). Morphospecies: F-11.

Identification: This putative species was identified as *P. monteithi* Zabka, 2012. The male-female complementarity was newly confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *Phintella debilis* by dorsum of male carapace with nine white patches of setae; and copulatory duct connected to posterior part of spermatheca.

***Phintella* sp. 12**

MOTU recognition: C3 in COI (bootstrap value = 96, posterior probability = 1), SN20 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), paraphyletic in 28S (part of S2). Morphospecies: M-5, F-5.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. debilis, P. monteithi* and *P. vittata* by dorsum of male carapace with three white patches of setae; and dorsum of female abdomen with black and white transverse bands.

***Phintella* sp. 2**

MOTU recognition: SN6 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), S3 in 28S (bootstrap value = 100, posterior probability = 1). Morphospecies: F-2.

Identification: This putative species is undescribed. The male is still unknown.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. aequipeiformis* by copulatory duct connected to anterior part of spermatheca. This species is distinguishable from *P. cavaleriei* by copulatory duct with a large diameter (about 1/3 of the diameter of spermatheca).

***Phintella cavaleriei* (Schenkel, 1963)**

MOTU recognition: C5 in COI (bootstrap value = 100, posterior probability = 1), SN7 in 16S-ND1 (bootstrap value = 100, posterior probability = 1).

Identification: This putative species was identified as the female of *P. cavaleriei* (Schenkel, 1963). Although this species was described based on both the male and female, the male was unable to be investigated by the present integrated taxonomy because of lack of males from Vietnam.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 2 by copulatory duct with a small diameter (about 1/4 of the diameter of spermatheca). This species is and distinguishable from *P. aequipeiformis* by female genitalia connected to anterior part of spermatheca.

***Phintella lepidus* Cao & Li, 2016**

MOTU recognition: C6 in COI (bootstrap value = 100, posterior probability = 1), SN8 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), S4 in 28S (bootstrap value = 99, posterior probability = 1).

Identification: This putative species was identified as *P. lepidus* Cao & Li, 2016. The male-female complementarity was reconfirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 9 by large embolus and developed retrolateral outgrowth present in anterior part of bulbus of *Male palp.*

***Phintella sancha* Cao & Li, 2016**

MOTU recognition: C7 in COI (bootstrap value = 98, posterior probability = 1), SN9 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), S5 in 28S (bootstrap value = 100, posterior probability = 1). Morphospecies: F-10.

Identification: This putative species was identified as *P. sancha* Cao & Li, 2016. The male-female complementarity was newly confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 4, *P.* sp. 7 and *P.* sp. 10 by the tibia of male palp with three retrolateral apophyses.

"*Laufeia squamata* (Zabka, 1985)"

MOTU recognition: C8 in COI (bootstrap value = 99, posterior probability = 1), S6 in 28S (bootstrap value = 96, posterior probability = 1). Morphospecies: M-2.

Identification: This putative species was identified as "*Laufeia squamata* (Zabka, 1985)". The male-female complementarity made by Logunov and Jäger (2015) was rejected by the present integrated taxonomy, and the corrected complementarity was proposed here. Furthermore, the present results of phylogenetic analysis confirmed that "*L. squamata*" belongs to the genus *Phintella*. The detailed discussion will be done in the Chapter 3 and 4.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. versicolor* and *P.* sp.6 by male palp with round bulbus. This species is distinguishable from *P.* sp. 1 by copulatory duct with a small diameter (smaller than 1/4 of the diameter of spermatheca).

***Phintella versicolor* (Koch, 1846)**

MOTU recognition: C9 in COI (bootstrap value = 99, posterior probability = 1), paraphyletic in 28S (part of S7).

Identification: This putative species was identified as *P. versicolor* (Koch, 1846). The male-female complementarity was reconfirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 1 by dorsum of female abdomen with two longitudinal gray or reddish brown streaks divided by yellowish field.

***Phintella* sp. 1**

MOTU recognition: C11 in COI (bootstrap value = 99, posterior probability = 1), paraphyletic in 28S (part of S7). Morphospecies: F-1.

Identification: This putative species is undescribed. The male is still unknown.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. versicolor* by dorsum of female abdomen covered with mixture of black and white spots of setae.

***Phintella vittata* (Koch, 1846)**

MOTU recognition: C10 in COI (bootstrap value = 95, posterior probability = 1), SN10+SN11 in 16S-ND1 (bootstrap value = 94, posterior probability = 0.99), S8 in 28S (bootstrap value = 99, posterior probability = 1).

Identification: This putative species was identified as *P. vittata* (Koch. 1846) and *P. suavis* (Simon, 1885). *P. vittata* was described based on both sexes, but *P. suavis* was described based on only the male. Body color pattern and structure of palp of the male of *P. suavis* are similar to those of in *P. vittata*. The conspecificity of the two nominal species was strongly supported by the present integrated taxonomy. The formal taxonomic treatment will be done in the Chapter 4.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 12 by body in both sexes covered with metallic setae. This species is distinguishable from *P.* sp. 13 by male palp with a thin and curved retrolateral tibial apophysis.

***Phintella* sp. 3**

MOTU recognition: C12 in COI (bootstrap value = 80, posterior probability = 1), SN12 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), paraphyletic in 28S (part of S9). Morphospecies: M-8, F-8.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 8 by anterior part of male palp with developed retrolateral outgrowth; and copulatory duct connected to posterior part of spermatheca.

***Phintella* sp. 8**

MOTU recognition: C19 in COI (bootstrap value = 98, posterior probability = 1), SN16 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), paraphyletic in 28S (part of S9). Morphospecies: M-11, F-12.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 3 by anterior part of male palp without retrolateral outgrowth; copulatory duct connected to anterior part of spermatheca.

***Phintella* sp. 4**

MOTU recognition: C13+C14 in COI (bootstrap value = 99, posterior probability = 1), SN13 in 16S-ND1 (bootstrap value = 95, posterior probability = 1), paraphyletic in 28S (part of S10). Morphospecies: M-9, F-9.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 7 by copulatory duct less than twice as long as the diameter of spermatheca; and copulatory opening located close to anterior part of spermatheca.

***Phintella* sp. 7**

MOTU recognition: C18 in COI (bootstrap value = 99, posterior probability = 1), SN15 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), paraphyletic in 28S (part of S10). Morphospecies: M-3, F-4.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 4 by copulatory duct about twice as long as the diameter of spermatheca; and copulatory opening located far from anterior part of spermatheca.

***Phintella* sp. 9**

MOTU recognition: C20 in COI (bootstrap value = 100, posterior probability = 1), SN17 (bootstrap value = 100, posterior probability = 1)16S-ND1), S11 in 28S (bootstrap value = 100, posterior probability = 1). Morphospecies: M-10.

Identification: This putative species is undescribed. The female is still unknown.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. lepidus* by male palp with thin and long embolus.

***Phintella* sp. 5**

MOTU recognition: C15+C16 in COI (bootstrap value = 99, posterior probability = 1), SN5 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), S12 in 28S (bootstrap value = 100, posterior probability = 1). Morphospecies: M-4, F-13.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. debilis, P. monteithi, P.* sp. 3 and *P.* sp. 8 by copulatory ducts with a large diameter (about 2/3 of the diameter of spermatheca).

***Phintella* sp. 13**

MOTU recognition: SN21 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), S13 in 28S (bootstrap value = 100, posterior probability = 1). Morphospecies: M-12

Identification: This putative species is undescribed. The female is still unknown.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. vittata* by male palp with a thick and straight retrolateral tibial apophysis.

***Phintella* sp. 10**

MOTU recognition: C21 in COI (bootstrap value = 89, posterior probability = 0.97), SN18 in 16S-ND1 (bootstrap value = 99, posterior probability = 1), paraphyletic in 28S (part of S14). Morphospecies: M-6, F-6.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 11 by large tooth present at basal end of fang furrow of male chelicera; and copulatory opening in ventral view located just behind the level of the anteriormost margin of spermatheca, and directed ventroanterad.

***Phintella* sp. 11**

MOTU recognition: C22 in COI (bootstrap value = 94, posterior probability = 0.98), SN19 in 16S-ND1 (bootstrap value = 99, posterior probability = 1), paraphyletic in 28S (part of S14). Morphospecies: M-7, F-7.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P.* sp. 10 by the small tooth present at basal end of fang furrow of male chelicera; and copulatory opening in ventral view located far behind the level of the posteriormost margin of spermatheca, and directing ventroposterad.

***Phintella* sp. 6**

MOTU recognition: C17 in COI (bootstrap value = 99, posterior probability = 1), SN14 in 16S-ND1 (bootstrap value = 100, posterior probability = 1), S15 in 28S (bootstrap value = 99, posterior probability = 1). Morphospecies: M-1, F-3.

Identification: This putative species is undescribed. The male-female complementarity was confirmed by the present integrated taxonomy.

Delimitation from phylogenetically closest species: This species is distinguishable from *P. versicolor* and *P.* sp. 1 by dorsal and lateral surfaces of female abdomen with yellow bands of seate.

2.4.2. Intra- and interspecific divergences in the COI dataset

Interspecific and intraspecific K2P divergences calculated based on the COI dataset (Table 2.7) highlight a very clear barcode gap: intraspecific divergences ranging from 0 % to 2.22%; interspecific divergences from 4.40 to 17.47. The maximum intraspecific divergence is lower than 1% in 14 species, between 1% and 2% in 3 species, and 2.22% in *Phintella debilis*.

Blagoev *et al*. (2016) revealed that the mean interspecific divergence between nearest–neighbor species (=sister species) was 10 times higher than the mean intraspecific divergence in Canadian spiders (7.85% vs. 0.78%), and seven times higher in Canadian salticid spiders (7.57% vs. 1.18%). Other studies on various arthropod taxa including spiders (Hebert *et al.*, 2003 for Lepidoptera; Barrett & Hebert, 2005 for spiders; Smith *et al.*, 2005 for Formicidae; Robinson *et al.*, 2009 for spiders; Renaud *et al.*, 2012 for Diptera; Glowska *et al.*, 2014 for syringophilid mites; Doña *et al.*, 2015 for feather mites) suggested that the interspecific divergence values of COI are usually greater than 2–3%, or the intraspecific divergence values of COI are usually less than 2–3%. The result of the present integrated taxonomy fits very well with these previous results of terrestrial arthropods.

The present study highlights that integrated taxonomy is especially powerful for revealing conspecific male-female complementarity, and subsequently solving synonymies and/or unifying the male-based and female-based classifications, as well as for discovering cryptic species. However integrated taxonomy can not be applied to cases where only a small number of specimens is available. Therefore, the “2–5% threshold” should be useful as a “scale” for estimating whether multiple species are present or not.

References

Andersson M. B. 1994. Sexual selection. Princeton University Press.

Barrett R. D. H., & Hebert P. D. N. 2005. Identifying spiders through DNA barcodes. Canadian Journal of Zoology 83: 481–491.

Bickford D., Lohman D. J., Sodhi N. S., Ng P. K., Meier R., Winker K., Ingram K. K., & Das I. 2006. Cryptic species as a window on diversity and conservation. Trends in Ecology & Evolution 22: 148–155.

Blagoev G. A., deWaard J. R., Ratnasingham S., deWaard S. L., Lu L., Robertson J., Telfer A. C., & Hebert D. N. 2016. Untangling taxonomy: a DNA barcode reference library for Canadian spiders. Molecular Ecology Resources 16: 325–341.

Bodner M. R., &. Maddison W. P. 2012. The biogeography and age of salticid spider radiations (Araneae: Salticidae). Molecular Phylogenetics and Evolution 65: 213–240.

Bösenberg W., Strand E. 1906. Japanische Spinnen. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 30: 93–422.

Cao X. W., Li S. Q., & Żabka M. 2016. The jumping spiders from Xishuangbanna, Yunnan, China (Araneae, Salticidae). ZooKeys 630: 43–104.

Crane J. 1949. Comparative biology of salticid spiders at Rancho Grande, Venezuela . Part 4. An analysis of display. Zoologica 34: 159–214.

Darwin C. 1871. The Descent of Man, and Selection in Relation to Sex. Murray, London.

De Bruyn M., Stelbrink B., Morley R. J., Hall R., Carvalho G. R., Cannon C. H., & Maiorano L. 2014. Borneo and Indochina are major evolutionary hotspots for Southeast Asian biodiversity. Systematic Biology 63(6): 879–901.

Diaz S. A., Moncada L. I., Murcia C. H., Lotta I. A., Matta N. E., & Adler P. H. 2015. Integrated taxonomy of a new species of black fly in the subgenus *Trichodagmia* (Diptera: Simuliidae) from the Páramo Region of Colombia. Zootaxa: 3914(5): 541–557.

Doña J., Diaz-Real J., Mironov S., Bazaga P., Serrano D., & Jovani R. 2015. DNA barcoding and minibarcoding as a powerful tool for feather mite studies. Molecular Ecology Resources 15: 1216–1225.

Dufour L. 1831. Descriptions et figures de quelques Arachnides nouvelles ou mal connues et procédé pour conserver à sec ces Invertébrés dans les collections. Annales des Sciences Naturelles, Zoologie, Paris 22: 355–371.

Edgar R. C. 2004. MUSCLE: multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32: 1792–1797.

Ekrem T., Stur E., & Hebert P. D. N. 2010. Females do count: Documenting Chironomidae (Diptera) species diversity using DNA barcoding. Organisms Diversity & Evolution 10: 397–408.

Ferri E., Barbuto M., Bain O., Galimberti A., Uni S., Guerrero R., Ferté H., Bandi C., Martin C., & Casiraghi, M. 2009. Integrated taxonomy: traditional approach and DNA barcoding for the identification of filarioid worms and related parasites (Nematoda). Frontiers in zoology 6(1): 1–12.

Fisher B., Smith M. A. 2008. A revision of Malagasy species of *Anochetus* Mayr and *Odontomachus* Latreille (Hymenoptera: Formicidae). PLoS One 3: 1–23.

Glowska E., Dragun-Damian A., Broda L., Dabert J., & Dabert M. 2014. DNA barcodes reveal female dimorphism in syringophilid mites (Actinotrichida: Prostigmata: Cheyletoidea): Stibarokris phoeniconaias and Ciconichenophilus phoeniconaias are conspecifi c. Folia Parasitologica 61: 272–276.

Hebert P. D. N., Cywinska A., Ball S. L., & deWaard J. R. 2003. Biological identifications through DNA barcodes. Proceedings of the Royal Society of London. Series B: Biological Sciences 270: 313–321.

Hedin M. C., & Maddison W. P. 2001. A combined molecular approach to phylogeny of the jumping spider subfamily Dendryphantinae (Araneae: Salticidae). Molecular Phylogenetics and Evolution 18(3): 386–403.

Hoisington-Lopez J. L., Waits L. P., & Sullivan J. 2012. Species limits and integrated taxonomy of the Idaho ground squirrel (*Urocitellus brunneus*): genetic and ecological differentiation. Journal of Mammalogy 93(2): 589–604.

Jackson R. R., & Harding D. P. 1982. Intraspecific interactions of *Holoplatys* sp. indet., a New Zealand jumping spider (Araneae: Salticidae). New Zealand journal of zoology 9(4): 487–510.

Jackson R. R. 1986. Web building, predatory versatility, and the evolution of the Salticidae. Spiders: Webs, Behavior, and Evolution 232–268.

Jackson R. R., & Pollard S. D. 1996. Predatory behavior of jumping spiders. Annual Review of Entomology 41: 287–308.

Jackson R. R., Pollard S. D., Nelson X. J., Edwards G. B., & Barrion A. T. 2001. Jumping spiders (Araneae: Salticidae) that feed on nectar. Journal of Zoology 255(1): 25–29.

Jobb G. 2011. TREEFINDER version of March 2011. Munich, Germany. Distributed by the author at www. treefinder. de.

Kekkonen M., & Hebert P. D. 2014. DNA barcode-based delineation of putative species: efficient start for taxonomic workflows. Molecular ecology resources 14(4): 706–715.

Koch C. L. 1846. Die Arachniden. Nürnberg, Dreizehnter Band, pp. 1–234, Vierzehnter Band 1–88.

Leavitt S. D., Moreau C. S., & Lumbsch H. T. 2015. The dynamic discipline of species delimitation: progress toward effectively recognizing species boundaries in natural populations. In Recent advances in lichenology 11–44.

Logunov D. V. 1999. Redefinition of the genus Habrocestoides Prószyński, 1992, with establishment of a new genus, *Chinattus* gen n. (Araneae: Salticidae). Bulletin of the British Arachnological Society 11: 139–149.

Marcos-García M. Á., Vujić A., Ricarte A., & Ståhls G. 2011. Towards an integrated taxonomy of the Merodon equestris species complex (Diptera: Syrphidae) including description of a new species, with additional data on Iberian Merodon. The Canadian Entomologist 143(4): 332–348.

Maddison W. P., & Hedin M. C. 2003. Jumping spider phylogeny (Araneae: Salticidae). Invertebrate Systematics 17: 529–549.

Maddison W. P., Zhang J. X., & Bodner M. R. 2007. A basal phylogenetic placement for the salticid spider Eupoa, with descriptions of two new species (Araneae: Salticidae). Zootaxa 1432(1): 23–33.

Maddison W. P., Bodner M. R., & Needham K. M. 2008. Salticid spider phylogeny revisited, with the discovery of a large Australasian clade (Araneae: Salticidae). Zootaxa 1893: 49–64

Maddison W. P., Li D., Bodner M., Zhang J., Xu X., Liu Q., & Liu F. 2014. The deep phylogeny of jumping spiders (Araneae, Salticidae). ZooKeys 440: 57–87.

Montagna M., Mereghetti V., Lencioni V., & Rossaro B. 2016. Integrated taxonomy and DNA barcoding of Alpine midges (Diptera: Chironomidae). PloS one 11(3), e0149673: 1–20.

Mayr E. 1942. Systematics and the origin of species, from the viewpoint of a zoologist. Harvard University Press 372 pp.

Myers N., Mittermeier R. A., Mittermeier C. G., Da Fonseca G. A., & Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403(6772): 853–858.

Peckham G. W. & Peckham E. G. 1889. Observations on sexual selection in spiders of the family Attidae. Occ. Pap. Wisconsin Natur. Hist. Soc. 1: 3–60.

Peckham G. W. & Peckham E. G. 1890. Additional observations on sexual selection in spiders of the family Attidae, with some remarks on Mr . Wallace's theory of sexual ornamentation. Occ. Pap. Wisconsin Natur. Hist. Soc. 1(1): 17–151 .

Peng X. J. & Xie L. P. 1995. Spiders of the genus *Habrocestoides* from China (Araneae: Salticidae). Bulletin of the British Arachnological Society 10: 57–64.

Pires A. C., Marinoni L. 2010. DNA barcoding and traditional taxonomy unified through Integrative Taxonomy: a view that challenges the debate questioning both methodologies. Biota Neotropica 10: 339–346.

Phung T. H. L., Yamasaki, T., & Eguchi, K. 2016. Conspecificity of *Phintella aequipeiformis* Zabka, 1985 and *P. lucai* Zabka, 1985 (Araneae: Salticidae) confirmed by DNA barcoding. Revue Suisse De Zoologie 123(2): 283–290.

Prószyński J. 1984. Atlas rysunków diagnostycznych mniej znanych Salticidae (Araneae). Wyższa Szkola Rolniczo-Pedagogiczna, Siedlcach 2: 1–177.

Puillandre N., Lambert A., Brouillet S., & Achaz G. 2012. ABGD, Automatic Barcode Gap Discovery for primary species delimitation. Molecular ecology 21(8): 1864–1877.

Ralls K. 1976. Mammals in which females are larger than males. The Quarterly Review of Biology 51: 245–276.

Ralls K., & Mesnick S. L. 2002. Sexual dimorphism. Encyclopedia of marine mammals. Academic Press, San Diego, CA: 1071–1078.

Renaud A. K., Savage J., Adamowicz S. J. 2012. DNA barcoding of Northern Nearctic Muscidae (Diptera) reveals high correspondence between morphological and molecular species limits. BMC Ecology 12(24): 1–15.

Richman D. B. 1982. Epigamic display in jumping spiders (Araneae, Salticidae) and its use in systematics. Journal of arachnology 10: 47–67.

Richman D. B. & Jackson R. R. 1992. A review of the ethology of jumping spiders (Araneae, Salticidae). Bulletin of the British Arachnological Society 9(2): 33–37.

Robinson E. A., Blagoev G. A., Hebert P.D.N., Adamowicz, S. J. 2009. Prospects for using DNA barcoding to identify spiders in species–rich genera. ZooKeys 16: 27–46.

Ronquist F., Huelsenbeck J. P. 2003 MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574.

Schwarz G. 1978. Estimating the dimension of a model. Ann. Statist. 6: 461–464.

Simon E. 1885. Matériaux pour servir à la faune arachnologiques de l'Asie méridionale. Bulletin de la Société Zoologique de France 10: 436–462.

Simon E. 1901a. Histoire naturelle des araignées. Paris 2: 381–668.

Simon E. 1901b. Descriptions d'arachnides nouveaux de la famille des Attidae (suite). Annales de la Société Entomologique de Belgique 45: 141–161.

Simon E. 1903. Etudes arachnologiques. 33e Mémoire. LIII. Arachnides recueillis à Phuc-Son (Annam) par M. H. Fruhstorfer (nov–dec. 1899). Annales de la Société Entomologique de France 71: 725–736.

Simon C., Frati F., Beckenbach A., Crespi B., Liu H., & Flook P. 1994. Evolution, weighting, and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. Annals of the entomological Society of America 87(6): 651–701.

Smith M. A., Fisher B. L., Hebert P. D. N. 2005. DNA barcoding for effective biodiversity assessment of a hyperdiverse arthropod group: the ants of Madagascar. Philosophical Transactions of the Royal Society B 360: 1825–1834.

Song D. X., Zhu M. S. & Chen J. 1999. The Spiders of China. Hebei University of Science and Techology Publishing House, Shijiazhuang 640 pp.

Sterling E. J, Hurley. M. M & Le M. D. 2006. Vietnam: a national history. Yale University Press. New Haven and London 444 pp.

Sugiura N. 1978. Further analysts of the data by akaike' s information criterion and the finite corrections. Communications in Statistics - Theory and Methods 7: 13–26.

Tamura K., Stecher G., Peterson D., Filipski A., Kumar S. 2013. MEGA6: Molecular evolutionary genetics analysis version 6.0. Molecular Biology and Evolution 30: 2725–2729.

Tanabe A. S. 2011. Kakusan4 and Aminosan: two programs for comparing nonpartitioned, proportional, and separate models for combined molecular phylogenetic analyses of multilocus sequence data. Molecular Ecology Resources 11: 914–921.

Tanikawa A. 2011. The first description of a male of *Paraplectana tsushimenis* (Araneae: Araneidae). Acta Arachnologica 60(2): 71–73.

Thorell T. 1887. Viaggio di L. Fea in Birmania e regioni vicine. II. Primo saggio sui ragni birmani. Annali del Museo Civico di Storia Naturale di Genova 25: 5–417.

Thorell T. 1891. Spindlar fran Nikobarerna och andra delar af Sodr a Asien till storre delen insamlade under K. Danska Korvetten Galatheas resa omkring jorden aren 1845–1847. Bihang till Kongl. Svenska vetenskaps-akademiens handlingar 24(2): 1–149.

World Spider Catalog 2017. World Spider Catalog. Natural History Museum Bern. Available at http://wsc.nmbe.ch, version 17.5 (accessed 2017).

Zabka M. 1985. Systematic and zoogeographic study on the family Salticidae (Araneae) from Vietnam. Annales Zoologici Warszawa 11: 1–485.

Zabka M. 2012. Phlegra Simon, 1876, Phintella Strand 1906 and Yamangalea Maddison, 2009 (Arachnida: Araneae: Salticidae) – new species and new generic records for Australia. Zootaxa 3176: 61–68.

Zhang J., Kapli P., Pavlidis P., & Stamatakis A. 2013. A general species delimitation method with applications to phylogenetic placements. Bioinformatics 29(22): 2869–2876.

Zhu X. C., Chen J., Chen R., Jiang L. Y., & Qiao G. X. 2017. DNA barcoding and species delimitation of Chaitophorinae (Hemiptera, Aphididae). ZooKeys 656: 25.

Table 2.1. Specimens using for the present integrated taxonomy.

	ID code	Sex	Preliminary sorting	COI	16S-ND1	28S	Identify	Locality
1	Sal-LP-0329	♂	*Phintella aepuipeiformis*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Phu Tho province, Xuan Son National Park
2	Sal-LP-0491	♂	*Phintella aepuipeiformis*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
3	Sal-LP-0531	♂	*Phintella aepuipeiformis*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
4	Sal-LP-0586	♂	*Phintella aepuipeiformis*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
5	Sal-LP-0622	♂	*Phintella aepuipeiformis*	C1	No data	S1	*Phintella aepuipeiformis*	Vietnam:, Ha Tinh province, Vu Quang National Park
6	Sal-LP-0731	♂	*Phintella aepuipeiformis*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
7	Sal-LP-0587	♂	*Phintella aepuipeiformis*	C1	SN1	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
8	Sal-LP-0148	♂	*Phintella bifurcilinea*	C2	No data	No data	*Phintella debilis*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
9	Sal-LP-0479	♀	*Phintella bifurcilinea*	C2	No data	No data	*Phintella debilis*	Vietnam: Ha noi city, Ba Vi district, Dong Mo
10	Sal-LP-0527	♂	*Phintella bifurcilinea*	C2	No data	S2	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
11	Sal-LP-0558	♂	*Phintella bifurcilinea*	C2	No data	S2	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
12	Sal-LP-0679	♂	*Phintella bifurcilinea*	C2	No data	No data	*Phintella debilis*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
13	Sal-LP-0680	♀	*Phintella bifurcilinea*	C2	SN2	No data	*Phintella debilis*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
14	Sal-LP-0681	♀	*Phintella bifurcilinea*	C2	SN2	No data	*Phintella debilis*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
15	Sal-LP-0689	♀	*Phintella bifurcilinea*	C2	No data	No data	*Phintella debilis*	Vietnam: Ha noi city, Ba Vi district, Dong Mo
16	Sal-LP-0709	♂	*Phintella bifurcilinea*	No data	No data	S2	*Phintella debilis*	Vietnam: Ha Tinh province, Vu Quang National Park

17	Sal-LP-0790	♂	*Phintella bifurcilinea*	No data	No data	S2	*Phintella debilis*	Vietnam: Kien Giang province, Phu Quoc National Park
18	Sal-LP-1065	♂	*Phintella bifurcilinea*	C2	No data	No data	*Phintella debilis*	Vietnam: Hanoi city, Bavi National Park
19	Sal-LP-1066	♀	*Phintella bifurcilinea*	C2	No data	S2	*Phintella debilis*	Vietnam: Hanoi city, Bavi National Park
20	Sal-LP-1294	♂	*Phintella bifurcilinea*	C2	SN2	S2	*Phintella debilis*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
21	Sal-LP-0250	♀	*Phintella cavaleriei*	C5	SN6	No data	*Phintella cavaleriei*	Vietnam: Lao Cai province, Sa Pa town
22	Sal-LP-0251	♀	*Phintella cavaleriei*	No data	SN6	No data	*Phintella cavaleriei*	Vietnam: Lao Cai province, Sa Pa town
23	Sal-LP-0526	♂	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
24	Sal-LP-0529	♀	*Phintella debilis*	No data	No data	No data	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
25	Sal-LP-0555	♂	*Phintella debilis*	C2	No data	S2	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
26	Sal-LP-0556	♀	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
27	Sal-LP-0628	♀	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Ha Tinh province, Vu Quang National Park
28	Sal-LP-0691	♂	*Phintella debilis*	C2	SN2	No data	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
29	Sal-LP-0692	♂	*Phintella debilis*	C2	SN2	No data	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
30	Sal-LP-0693	♀	*Phintella debilis*	C2	SN2	S2	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
31	Sal-LP-0694	♀	*Phintella debilis*	C2	SN2	S2	*Phintella debilis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
32	Sal-LP-0701	♂	*Phintella debilis*	No data	No data	S2	*Phintella debilis*	Vietnam: Ha Tinh province, Vu Quang National Park
33	Sal-LP-0702	♀	*Phintella debilis*	C2	No data	S2	*Phintella debilis*	Vietnam: Ha Tinh province, Vu Quang National Park
34	Sal-LP-0706	♂	*Phintella debilis*	C2	No data	S2	*Phintella debilis*	Vietnam: Ha Tinh province, Vu Quang National Park
35	Sal-LP-0860	♂	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Tay Ninh povince, Lo Go Xa Mat

36	Sal-LP-1110	♂	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Daklak province, Chu Yang Sin National Park
37	Sal-LP-1281	♂	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
38	Sal-LP-1453	♂	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Nghe An province, Pu Mat National Park
39	Sal-LP-1454	♀	*Phintella debilis*	C2	No data	No data	*Phintella debilis*	Vietnam: Nghe An province, Pu Mat National Park
40	Sal-LP-0986	♀	*Phintella lepidus*	C6	SN7	S4	*Phintella lepidus*	Vietnam: Tay Ninh povince, Lo Go Xa Mat National Park
41	Sal-LP-0987	♂	*Phintella lepidus*	C6	SN7	No data	*Phintella lepidus*	Vietnam: Tay Ninh povince, Lo Go Xa Mat National Park
42	Sal-LP-0996	♀	*Phintella lepidus*	C6	SN7	S4	*Phintella lepidus*	Vietnam: Kien Giang province, Phu Quoc National Park
43	Sal-LP-0490	♀	*Phintella lucai*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
44	Sal-LP-0588	♀	*Phintella lucai*	C1	SN1	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
45	Sal-LP-0589	♀	*Phintella lucai*	C1	No data	S1	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
46	Sal-LP-0726	♀	*Phintella lucai*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
47	Sal-LP-0727	♀	*Phintella lucai*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
48	Sal-LP-0728	♀	*Phintella lucai*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
49	Sal-LP-0729	♀	*Phintella lucai*	C1	No data	No data	*Phintella aepuipeiformis*	Vietnam: Ha Tinh province, Vu Quang National Park
50	Sal-LP-1205	♀	F-11	C4	SN3	S2	*Phintella monteithi*	Vietnam: Daklak province, Yokdon National Park
51	Sal-LP-1206	♂	*Phintella monteithi*	C4	SN3	S2	*Phintella monteithi*	Vietnam: Daklak province, Yokdon National Park
52	Sal-LP-1207	♂	*Phintella monteithi*	C4	SN3	No data	*Phintella monteithi*	Vietnam: Daklak province, Yokdon National Park
53	Sal-LP-1166	♂	*Phintella sancha*	C7	SN8	No data	*Phintella sancha*	Vietnam: Daklak province, Chu Yang Sin National Park
54	Sal-LP-1204	♀	F10	C7	SN8	S5	*Phintella sancha*	Vietnam: Daklak province, Chu Yang Sin National Park

55	Sal-LP-0204	♂	*Phintella versicolor*	C9	No data	No data	*Phintella versicolor*	Vietnam: Hai Phong province, Bach Long Vi island
56	Sal-LP-0271	♂	*Phintella versicolor*	C9	No data	No data	*Phintella versicolor*	Vietnam: Lao Cai province, Sa Pa town
57	Sal-LP-0468	♀	*Phintella versicolor*	C9	No data	S7	*Phintella versicolor*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
58	Sal-LP-0553	♀	*Phintella versicolor*	C9	No data	No data	*Phintella versicolor*	Vienam: Tuyen Quang province, Na Hang Nature Resever
59	Sal-LP-0671	♂	*Phintella versicolor*	C9	No data	No data	*Phintella versicolor*	Vietnam: Hanoi city, Ba Vi district, Dong Thai
60	Sal-LP-0476	♂	*Phintella vittata*	C10	No data	No data	*Phintella vittata*	Vietnam: Hanoi city, Bavi district, Dong Mo
61	Sal-LP-0477	♀	*Phintella vittata*	C10	No data	No data	*Phintella vittata*	Vietnam: Hanoi city, Bavi district, Dong Mo
62	Sal-LP-0674	♀	*Phintella vittata*	C10	No data	No data	*Phintella vittata*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
63	Sal-LP-0675	♂	*Phintella suavis*	C10	No data	No data	*Phintella vittata*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
64	Sal-LP-0768	♂	*Phintella vittata*	C10	No data	No data	*Phintella vittata*	Vietnam: Kien Giang province, Phu Quoc National Park
65	Sal-LP-0769	♀	*Phintella vittata*	C10	No data	No data	*Phintella vittata*	Vietnam: Kien Giang province, Phu Quoc National Park
66	Sal-LP-1549	♂	*Phintella suavis*	No data	No data	S8	*Phintella vittata*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
67	Sal-LP-1550	♂	*Phintella suavis*	No data	SN9	S8	*Phintella vittata*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
68	Sal-LP-1551	♂	*Phintella vittata*	No data	No data	No data	*Phintella vittata*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
69	Sal-LP-1552	♂	*Phintella vittata*	No data	SN9	S8	*Phintella vittata*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
70	Sal-LP-1553	♂	*Phintella vittata*	No data	No data	S8	*Phintella vittata*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
71	Sal-LP-1557	♀	*Phintella vittata*	No data	SN9	S8	*Phintella vittata*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
72	Sal-LP-1558	♀	*Phintella vittata*	No data	SN9	S8	*Phintella vittata*	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
73	Sal-LP-0582	♀	F-1	C11	No data	No data	*Phintella* sp. 1	Vietnam: Tuyen Quang province, Na Hang Nature Reserve

74	Sal-LP-0695	♀	F-1	C11	No data	S7	*Phintella* sp. 1	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
75	Sal-LP-0160	♀	F-2	No data	SN5	S3	*Phintella* sp. 2	Vietnam: Vinh Phuc province, Tam Dao National Park
76	Sal-LP-1067	♂	M-8	No data	No data	S9	*Phintella* sp. 3	Vietnam: Hanoi city, Ba Vi National Park
77	Sal-LP-1068	♀	F-8	C12	SN10	S9	*Phintella* sp. 3	Vietnam: Hanoi city, Ba Vi National Park
78	Sal-LP-1069	♂	M-8	C12	No data	No data	*Phintella* sp. 3	Vietnam: Hanoi city, Ba Vi National Park
79	Sal-LP-1070	♂	F-8	C12	No data	No data	*Phintella* sp. 3	Vietnam: Hanoi city, Ba Vi National Park
80	Sal-LP-1313	♀	F-8	C12	SN10	No data	*Phintella* sp. 3	Vietnam: Thanh Hoa province, Ben En National Park
81	Sal-LP-1455	♂	M-8	C12	SN10	No data	*Phintella* sp. 3	Vietnam: Nghe An province, Pu Mat National Park
82	Sal-LP-1158	♂	M-9	C13	SN11	S10	*Phintella* sp. 4	Vietnam: Daklak province, Chu Yang Sin National Park
83	Sal-LP-1159	♂	M-9	C13	SN11	No data	*Phintella* sp. 4	Vietnam: Daklak province, Chu Yang Sin National Park
84	Sal-LP-1164	♀	F-9	C13	SN11	No data	*Phintella* sp. 4	Vietnam: Daklak province, Chu Yang Sin National Park
85	Sal-LP-1165	♀	F-9	C13	No data	S10	*Phintella* sp. 4	Vietnam: Daklak province, Chu Yang Sin National Park
86	Sal-LP-0720	♂	M-4	C14	SN4	No data	*Phintella* sp. 5	Vietnam: Ha Tinh province, Vu Quang National Park
87	Sal-LP-0732	♀	F-13	C14	No data	No data	*Phintella* sp. 5	Vietnam: Ha Tinh province, Vu Quang National Park
88	Sal-LP-1673	♂	M-4	No data	No data	S12	*Phintella* sp. 5	Vietnam: Gia Lai province, K'Bang district
89	Sal-LP-1674	♀	F-13	C14	SN4	No data	*Phintella* sp. 5	Vietnam: Gia Lai province, K'Bang district
90	Sal-LP-1675	♀	F-13	C14	SN4	No data	*Phintella* sp. 5	Vietnam: Gia Lai province, K'Bang district
91	Sal-LP-1714	♂	M-4	C14	No data	No data	*Phintella* sp. 5	Vietnam: Gia Lai province, K'Bang district
92	Sal-LP-1715	♂	M-4	C14	No data	No data	*Phintella* sp. 5	Vietnam: Gia Lai province, K'Bang district

93	Sal-LP-0467	♂	M-1	C15	No data	S15	*Phintella sp. 6*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
94	Sal-LP-0475	♀	F-3	C15	No data	S15	*Phintella sp. 6*	Vietnam: Vinh Phuc province, Me Linh Biodiversity station
95	Sal-LP-0644	♀	F-3	C15	No data	S15	*Phintella sp. 6*	Vietnam: Ha Tinh province, Vu Quang National Park
96	Sal-LP-0669	♀	F-3	No data	No data	No data	*Phintella sp. 6*	Vietnam: Ha Tinh province, Vu Quang National Park
97	Sal-LP-1603	♀	F-3	C15	SN12	No data	*Phintella sp. 6*	Vietnam: Thanh Hoa province, Ben En National Park
98	Sal-LP-0590	♂	M-3	C16	No data	S10	*Phintella* sp. 7	Vietnam: Ha Tinh province, Vu Quang National Park
99	Sal-LP-0591	♂	M-3	C16	SN13	No data	*Phintella* sp. 7	Vietnam: Ha Tinh province, Vu Quang National Park
100	Sal-LP-0602	♀	F-4	C16	No data	S10	*Phintella* sp. 7	Vietnam: Ha Tinh province, Vu Quang National Park
101	Sal-LP-0630	♂	M-3	C16	No data	No data	*Phintella* sp. 7	Vietnam: Ha Tinh province, Vu Quang National Park
102	Sal-LP-1422	♀	F-4	C16	SN13	No data	*Phintella* sp. 7	Vietnam: Thanh Hoa province, Ben En National Park
103	Sal-LP-1424	♂	M-3	C16	SN13	No data	*Phintella* sp. 7	Vietnam: Thanh Hoa province, Ben En National Park
104	Sal-LP-1383	♂	M-11	C17	SN14	S9	*Phintella* sp. 8	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
105	Sal-LP-1492	♀	F-12	C17	SN14	S9	*Phintella* sp. 8	Vietnam: Nghe An province, Pu Mat National Park
106	Sal-LP-1505	♂	M-11	C17	No data	No data	*Phintella* sp. 8	Vietnam: Quang Tri province, Dakrong Nature Resever
107	Sal-LP-1567	♂	M-11	C17	No data	S9	*Phintella* sp. 8	Vietnam: Thanh Hoa province, Xuan Lien Nature Reserve
108	Sal-LP-1681	♂	M-11	C17	No data	S9	*Phintella* sp. 8	Vietnam: Gia Lai province, K'Bang district
109	Sal-LP-1203	♂	M-10	C18	SN15	S11	*Phintella* sp. 9	Vietnam: Daklak province, Yokdon National Park
110	Sal-LP-0775	♂	M-6	C19	No data	No data	*Phintella* sp. 10	Vietnam: Kien Giang province, Phu Quoc National Park
111	Sal-LP-0782	♀	F-6	C19	No data	No data	*Phintella* sp. 10	Vietnam: Kien Giang province, Phu Quoc National Park

112	Sal-LP-0869	♀	F-6	C19	SN16	No data	*Phintella* sp. 10	Vietnam: Tay Ninh province, Lo Go Xa Mat National Park
113	Sal-LP-0946	♂	M-6	C19	SN16	No data	*Phintella* sp. 10	Vietnam: Tay Ninh province, Lo Go Xa Mat National Park
114	Sal-LP-0967	♀	F-6	C19	No data	No data	*Phintella* sp. 10	Vietnam: Tay Ninh province, Lo Go Xa Mat National Park
115	Sal-LP-0969	♀	F-6	C19	No data	No data	*Phintella* sp. 10	Vietnam: Tay Ninh province, Lo Go Xa Mat National Park
116	Sal-LP-1676	♂	M-6	C19	SN16	No data	*Phintella* sp. 10	Vietnam: Gia Lai province, K'Bang district
117	Sal-LP-1677	♀	F-6	C19	SN16	S14	*Phintella* sp. 10	Vietnam: Gia Lai province, K'Bang district
118	Sal-LP-1678	♂	M-6	No data	No data	S14	*Phintella* sp. 10	Vietnam: Gia Lai province, K'Bang district
119	Sal-LP-0770	♀	F-7	C20	SN17	No data	*Phintella* sp. 11	Vietnam: Kien Giang province, Phu Quoc National Park
120	Sal-LP-0826	♂	M-7	No data	SN17	No data	*Phintella* sp. 11	Vietnam: Kien Giang province, Phu Quoc National Park
121	Sal-LP-0827	♂	M-7	No data	SN17	No data	*Phintella* sp. 11	Vietnam: Kien Giang province, Phu Quoc National Park
122	Sal-LP-0828	♀	F-7	C20	No data	No data	*Phintella* sp. 11	Vietnam: Kien Giang province, Phu Quoc National Park
123	Sal-LP-0958	♂	M-7	C20	No data	No data	*Phintella* sp. 11	Vietnam: Tay Ninh province, Lo Go Xa Mat National Park
124	Sal-LP-0999	♀	F-7	C20	SN17	S14	*Phintella* sp. 11	Vietnam: Kien Giang province, Phu Quoc National Park
125	Sal-LP-1000	♀	F-7	C20	No data	No data	*Phintella* sp. 11	Vietnam: Kien Giang province, Phu Quoc National Park
126	Sal-LP-1001	♀	F-7	C20	No data	No data	*Phintella* sp. 11	Vietnam: Kien Giang province, Phu Quoc National Park
127	Sal-LP-0632	♂	M-5	C3	SN18	S2	*Phintella* sp. 12	Vietnam: Ha Tinh province, Vu Quang National Park
128	Sal-LP-0721	♀	F-5	C3	SN18	S2	*Phintella* sp. 12	Vietnam: Ha Tinh province, Vu Quang National Park
129	Sal-LP-1592	♂	M-12	No data	SN19	S13	*Phintella* sp. 13	Vietnam: Thanh Hoa province, Ben En National Park
130	Sal-LP-0536	♂	M-2	C8	No data	No data	*Laufeia squamata*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve

131	Sal-LP-0568	♀	*Laufeia squamata*	C8	No data	No data	*Laufeia squamata*	Vietnam: Tuyen Quang province, Na Hang Nature Reserve
132	Sal-LP-0636	♂	M-2	C8	No data	S6	*Laufeia quamata*	Vietnam: Ha Tinh province, Vu Quang National Park
133	Sal-LP-0637	♂	M-2	C8	No data	No data	*Laufeia squamata*	Vietnam: Ha Tinh province, Vu Quang National Park
134	Sal-LP-0711	♀	*Laufeia squamata*	C8	No data	No data	*Laufeia squamata*	Vietnam: Ha Tinh province, Vu Quang National Park
135	Sal-LP-0712	♀	*Laufeia squamata*	No data	No data	S6	*Laufeia squamata*	Vietnam: Ha Tinh province, Vu Quang National Park
136	Sal-LP-0831	♀	*Cosmophasis* sp.		No data	No data	*Cosmophasis* sp.	Vietnam: Kien Giang province, Phu Quoc National Park
137	Sal-LP-0201	♂	*Menemerus bivitattus*		No data	No data	*Menemerus bivitattus*	Vietnam: Hai Phong province, Bach Long Vi island
138	Sal-LP-0207	♀	*Menemerus bivitattus*		No data		*Menemerus bivitattus*	Vietnam: Hai Phong province, Bach Long Vi island
139	Sal-LP-0353	♂	*Siler severus*			No data	*Siler severus*	Vietnam: Lao Cai province, Sapa town
140	Sal-LP-0354	♂	*Siler severus*		No data	No data	*Siler severus*	Vietnam: Lao Cai province, Sapa town
141	Sal-LP-0101	♂	*Telamonia festiva*				*Telamonia festiva*	Vietnam: Vinh Phuc province, MeLinh Biodiversity station
142	Sal-LP-0294	♀	*Telamonia festiva*	No data	No data		*Telamonia festiva*	Vietnam: Hai Phong province, Cat Ba National Park
143	TSG01	♂	*Chrysilla lauta*		No data	No data	*Chrysilla lauta*	Thailand

Table 2.2. Primers used for PCR amplification and sequencing

Gen region	Primer name	Primer sequence	Reference
COI	Forward: C1-J-1718	5’ GGAGGATTTGGAAATTGATTAGTTCC 3’	Simon *et al.*, 1994
	Forward: C1-LP–F-1718	5’ GGAGGTTTTGGAAATTGATTAGTTCC 3’	Simon *et al.*, 1994 (with the 6th bp changed from A to T)
	Reverse: C1-LP-R-2667	5’ CCAGCYATAATAGCAAATACAGCYC 3’	This study
	Reverse: C1-N-2776	5’ GGATAATCAGAATATCGTCGAGG 3’	Hedin & Maddison, 2001
	Reverse: C1-N-2797	5’ GGTAATCTGAATAACGTCGAGG 3’	Simon *et al.*, 1994 (reverse primer of C1-J-2797)
16S-ND1	Forward: 16S-ND1-WPM-F1	5’ GCRTCTCTRAAAGGTTG 3’	Zang & Maddison, 2013
	Reverse: 16S-ND1-WPM-R3	5’ CGCCTGTTTAACAAAAAC 3’	Zang & Maddison, 2013
28S	Forward: 28S-TY-F3	5’ ATGTGGCGTTTAGGAGTGAGC 3’	Yamasaki, unpublished
	Reverse: 28S-13-R	5’ GCT ATC CTG AGG GAA ACT TCG G 3’	Auwera *et al.*, 1993
	Reverse: 28S-LP-R1	5’ CCACCAGAGTTTCCTCTGGCTT 3’	This study

Table 2.3. MOTU counts proposed by ABGD (Puillandre *et al.*, 2012).

Gene markers	**Substitution model**	**Partition**	**Prior intraspecific maximal divergence (P)**							
			0.0010	0.0017	0.0028	0.0046	0.0077	0.0129	0.0215	0.0359
COI	P-distance (simple)	Initial	20	20	20	20	20	20		
		Recursive	22	22	22	21	21	20		
	Kimura 2-parameter (K2P)	Initial	20	20	20	20	20	20		
		Recursive	41	33	21	21	21	20		
	Jukes-Cantor (JC69)	Initial	20	20	20	20	20	20		
		Recursive	**43**	33	21	21	21	20		
16S-ND1	P-distance	Initial	16	16	16	16	16	16	16	
		Recursive	19	19	19	19	19	17	17	
	K2P	Initial	16	16	16	16	16	16	16	16
		Recursive	**20**	19	19	19	19	17	17	17
	JC69	Initial	16	16	16	16	16	16	16	16
		Recursive	**20**	19	19	19	19	17	17	17
28S	P-distance	Initial	14	14	14	14	6	6		
		Recursive	18	18	18	14	8	6		
	K2P	Initial	16	16	16	16	6	4		
		Recursive	**22**	**22**	21	21	6	4		
	JC69	Initial	10	10	10	10	10	6		
		Recursive	21	21	20	20	11	8		

Table 2.4. Evaluation of the MOTUs resulting from ABGD and bPTP analyses by phylogenetic criterion based on COI.

ABGD-based MOTUs	bPTP-based MOTUs		Phylogenetic Criterion		
	BS	ML	MOTUs	Bootstrap value	Posterior probability
MOTU-1	MOTU-1	MOTU-1	C1	100	1
MOTU-2					
MOTU-3					
MOTU-4					
MOTU-5					
MOTU-6					
MOTU-7	MOTU-2	MOTU-2	C2	97	1
MOTU-8					
MOTU-9					
MOTU-10					
MOTU-11					
MOTU-12	MOTU-3				
MOTU-13					
MOTU-14	MOTU-4				
MOTU-15					
MOTU-16					
MOTU-17					
MOTU-18					
MOTU-19					
MOTU-20					
MOTU-21	MOTU-5	MOTU-3	C3	96	1
MOTU-22	MOTU-6	MOTU-4	C4	99	1
MOTU-23	MOTU-7	MOTU-5	C5	100	1
MOTU-24	MOTU-8,	MOTU-6	C6	100	1
	MOTU-9	MOTU-7			
MOTU-25	MOTU-10	MOTU-8	C7	98	1
MOTU-26	MOTU-11	MOTU-9	C8	99	1
MOTU-27					
MOTU-28	MOTU-12	MOTU-10	C9	99	1
	MOTU-13	MOTU-11			
MOTU-29	MOTU-14	MOTU-12	C10	95	1
MOTU-30	MOTU-15	MOTU-13	C11	99	1

MOTU-31	MOTU-16	MOTU-14	C12	80	1
MOTU-32	MOTU-17	MOTU-15	C13	99	1
	MOTU-18	MOTU-16			
MOTU-33	MOTU-19	MOTU-17	C14	99	1
MOTU-34	MOTU-20	MOTU-18			
MOTU-35	MOTU-21	MOTU-19	C15	99	1
MOTU-36	MOTU-22	MOTU-20	C16	99	1
MOTU-37	MOTU-23	MOTU-21	C17	98	1
MOTU-38	MOTU-24	MOTU-22	C18	100	1
MOTU-39	MOTU-25	MOTU-23	C19	89	0.97
MOTU-40	MOTU-26	MOTU-24	C20	94	0.98
MOTU-41					
MOTU-42					
MOTU-43					
43 MOTUs	**26 MOTUs**	**24 MOTUs**	**20 MOTUs**		

Table 2.5. Evaluation of the MOTUs resulting from ABGD and bPTP analyses by phylogenetic criterion based on 16S-ND1.

ABGD-based MOTUs	**bPTP-based MOTUs**		**Phylogenetic Criterion**		
	BS	**ML**	**MOTUs**	Bootstrap value	Posterior probability
MOTU-1	MOTU-1	MOTU-1	SN1	100	1
MOTU-2	MOTU-2	MOTU-2	SN2	100	1
MOTU-3					
MOTU-4	MOTU-3	MOTU-3	SN3	99	1
MOTU-5	MOTU-4	MOTU-4	SN4	100	1
MOTU-6	MOTU-5	MOTU-5	SN5	100	1
MOTU-7	MOTU-6	MOTU-6	SN6	100	1
MOTU-8	MOTU-7	MOTU-7	SN7	100	1
MOTU-9	MOTU-8	MOTU-8	SN8	100	1
MOTU-10	MOTU-9	MOTU-9	SN9	100	1
	MOTU-10	MOTU-10	SN10	94	0.99
MOTU-11	MOTU-11	MOTU-11	SN11	100	1
MOTU-12	MOTU-12	MOTU-12	SN12	95	1
MOTU-13	MOTU-13	MOTU-13	SN13	100	1
MOTU-14	MOTU-14	MOTU-14	SN14	100	1
MOTU-15	MOTU-15	MOTU-15	SN15	100	1
MOTU-16	MOTU-16	MOTU-16	SN16	100	1
MOTU-17	MOTU-17	MOTU-17	SN17	99	1
MOTU-18	MOTU-18	MOTU-18	SN18	99	1
MOTU-19	MOTU-19	MOTU-19	SN19	100	1
MOTU-20	MOTU-20	MOTU-20	SN20	100	1
20 MOTUs	**20 MOTUs**	**20 MOTUs**	**20 MOTUs**		

Table 2.6. Evaluation of ABGD-based and bPTP-based MOTU-partitionings by phylogenetic criterion based on 28S.

ABGD-based MOTUs	**bPTP-based MOTUs**		**Phylogenetic Criterion**		
	BS	**ML**	**MOTUs**	Bootstrap value	Posterior probability
MOTU-1	MOTU-1	MOTU-1	S1	100	1
MOTU-2	MOTU-2	MOTU-2	S2	78	1
MOTU-3					
MOTU-4,	MOTU-3				
MOTU-5					
MOTU-6,					
MOTU-7					
MOTU-8	MOTU-4				
MOTU-9	MOTU-5	MOTU-3	S3	100	1
MOTU-10	MOTU-6	MOTU-4	S4	99	1
MOTU-11	MOTU-7	MOTU-5	S5	100	1
MOTU-12	MOTU-8	MOTU-6	S6	96	1
MOTU-13	MOTU-9	MOTU-7	S7	99	1
MOTU-14	MOTU-10	MOTU-8	S8	99	1
MOTU-15	MOTU-11	MOTU-9	S9	94	1
MOTU-16					
MOTU-17	MOTU-12	MOTU-10	S10	99	0.98
MOTU-18	MOTU-13	MOTU-11	S11	100	1
MOTU-19	MOTU-14	MOTU-12	S12	100	1
MOTU-20	MOTU-15	MOTU-13	S13	100	1
MOTU-21	MOTU-16	MOTU-14	S14	100	1
MOTU-22	MOTU-17	MOTU-15	S15	99	1
22 MOTUs	**17 MOTUs**	**15 MOTUs**	**15 MOTUs**		

Table 2.7. Final identification of the species recognized by the present integrated taxonomy, and the range of intraspecific and interspecific K2P divergences based on COI dataset. N: number of specimens used for DNA barcoding.

Phylogenetic Criterion (MOTUs)			**Morphology Criterion**		**Final Identification**	**K2P divergence based on COI**		
COI	**16S-ND1**	**28S**	**Putative species**	**Male-female complementarity**		**Intraspecific**	**Interspecific**	**N**
C1	SN1	S1	PS1	Newly confirmed	*P. aequipeiformis* ♂♀	0 – 0.77	7.20 – 16.91	14
C2	SN2	S2	PS2	Re-confirmed	*P. debilis* ♂♀	0 – 2.22	5.10 – 16.67	26
C4	SN3		PS3	Newly confirmed	*P. monteithi* ♂♀	0 – 0.11	5.10 – 16.80	3
C3	SN19		PS4	Newly confirmed	*P.* sp. 12 ♂♀	0.11	7.68 – 14.36	2
No data	SN5	S3	PS5	Unknown	*P.* sp. 2 ♀	-	-	0
C5	SN6	No data	PS6	Unknown	*P. cavaleriei* ♀	–	7.20 – 15.31	1
C6	SN7	S4	PS7	Re-confirmed	*P. lepidus* ♂♀	0.44 – 1.55	9.27 – 16.10	3
C7	SN8	S5	PS8	Newly confirmed	*P. sancha* ♂♀	0.11	10.12 – 16.52	2
C8	No data	S6	PS9	Newly confirmed	*L. squamata* ♂♀	0 – 0.33	10.37 – 16.23	5
C9	No data	S7	PS10	Re-confirmed	*P. versicolor* ♂♀	0 – 0.55	5.91 – 16.49	4
C11	No data		PS11	Unknown	*P.* sp. 1 ♀	0.11	5.91 – 15.04	2
C10	SN9 / SN10	S8	PS12	Re-confirmed	*P. vittata* ♂♀	0	8.30 – 17.23	6
C12	SN11	S9	PS13	Newly confirmed	*P.* sp. 3 ♂♀	0 – 0.44	5.12 – 17.47	5

C17	SN15		PS14	Newly confirmed	*P.* sp. 8 ♂♀	0 – 0.33	5.12 – 16.38	5
C13	SN12	S10	PS15	Newly confirmed	*P.* sp. 4 ♂♀	0.11 – 1.21	7.60 – 15.59	4
C16	SN14		PS16	Newly confirmed	*P.* sp. 7 ♂♀	0.11 – 0.77	7.60 – 16.64	6
C18	SN16	S11	PS17	Unknown	*P.* sp. 9 ♂	–	9.27 – 14.50	1
C14	SN4	S12	PS18	Newly confirmed	*P.* sp. 5 ♂♀	0 – 1.10	8.06 – 16.93	6
No data	SN20	S13	PS19	Unknown	*P.* sp. 13 ♂	-	-	0
C19	SN17	S14	PS20	Newly confirmed	*P.* sp. 10 ♂♀	0 – 0.77	4.40 – 16.52	8
C20	SN18		PS21	Newly confirmed	*P.* sp. 11 ♂♀	0 – 0.55	4.40 – 16.22	6
C15	SN13	S15	PS22	Newly confirmed	*P.* sp. 6 ♂♀	0	6.85 – 15.30	4
22 MOTUs	**20 MOTUs**	**15 MOTUs**		**22 MOTUs**	**22 species**	**0 – 2.22**	**4.40 – 17.47**	**113**

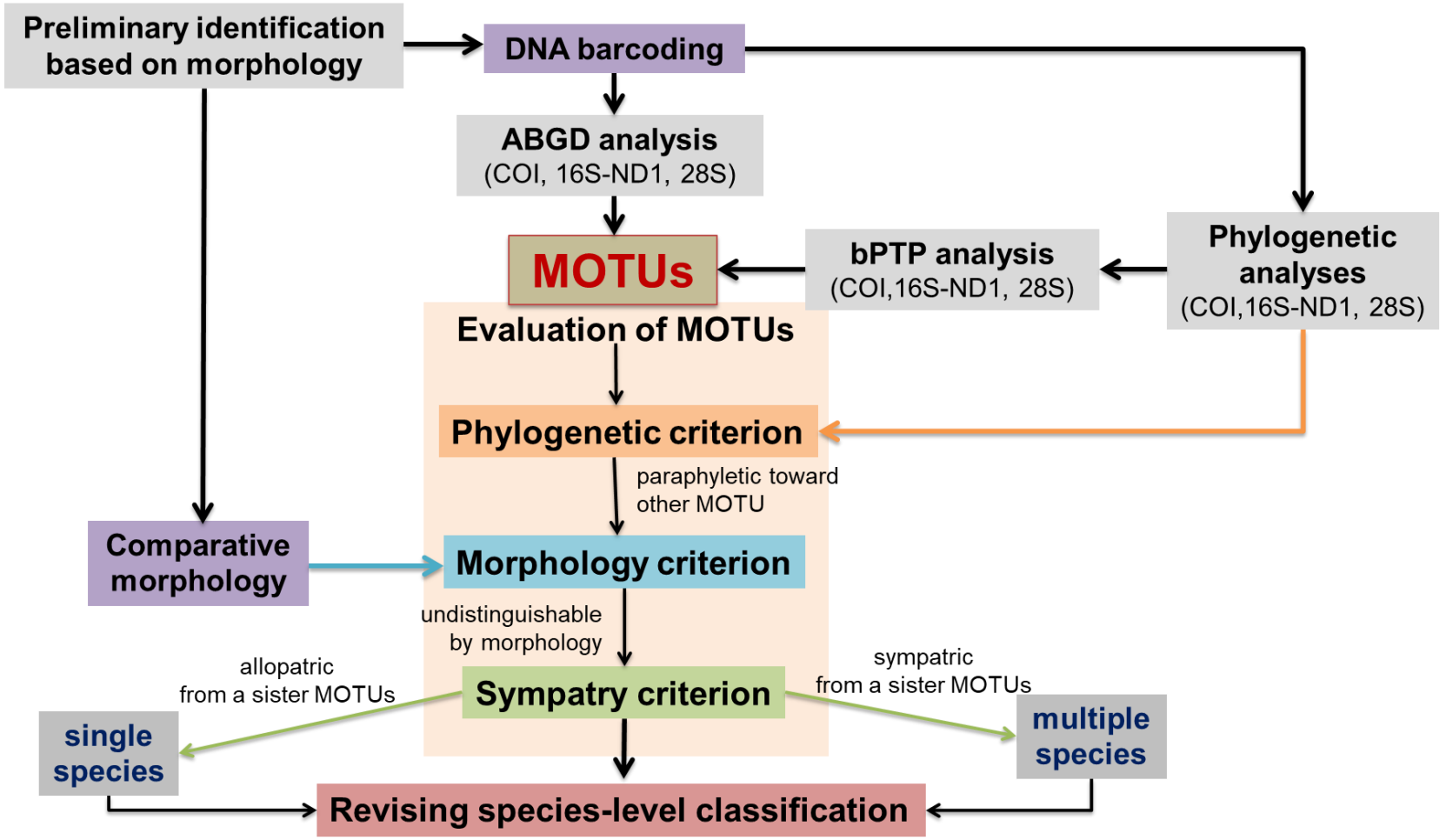

Figure 2.1. The diagram of the integrated taxonomy designed for the present study by referring to Puillandre *et al.* (2012), Zhang *et al.* (2013), Kekkonen & Hebert (2014), Leavitt *et al.* (2015), Montagna *et. al.* (2016) and Zhu *et al.* (2017).

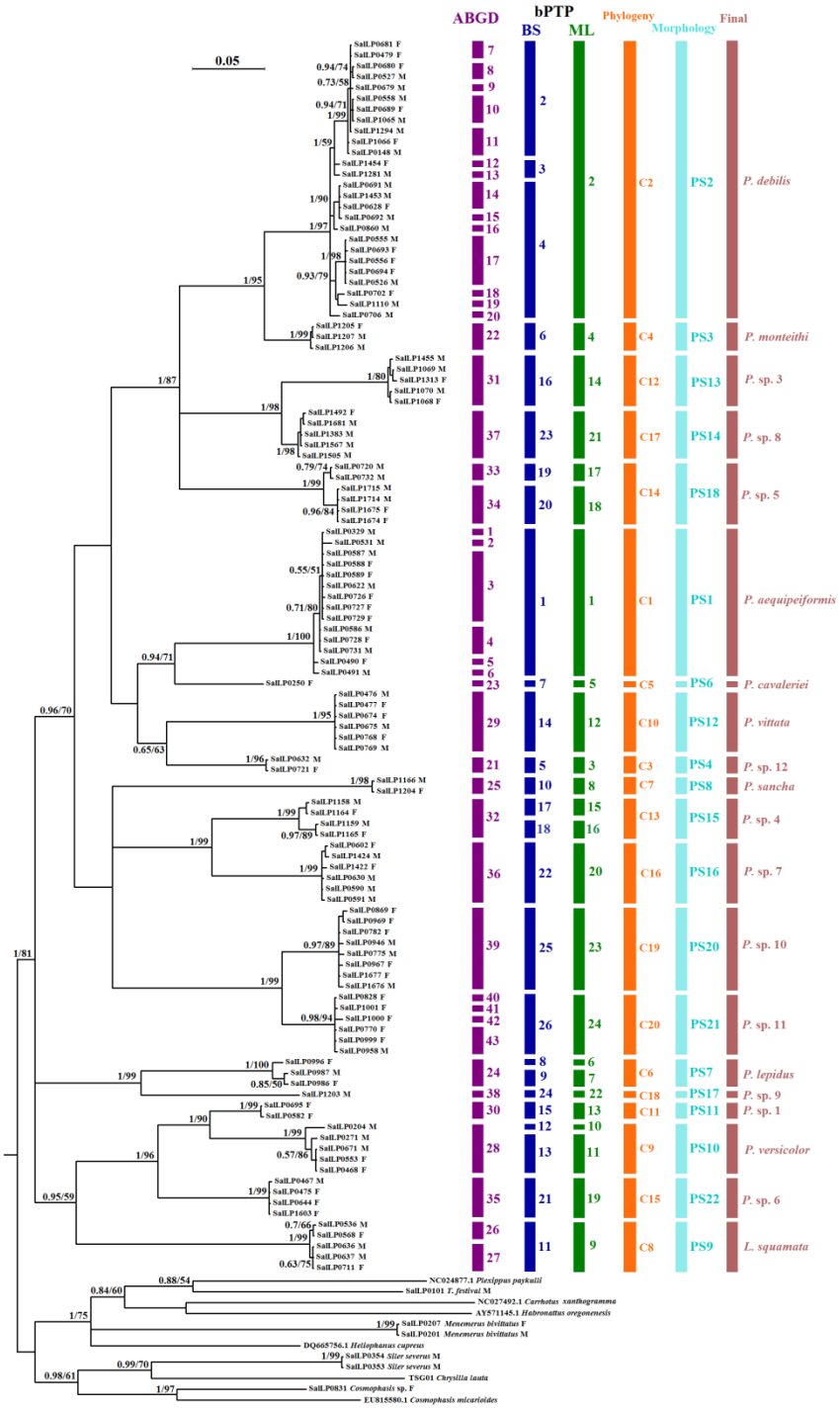

Figure 2.2. Basian phylogenetic tree based on COI dataset, and MOTU-partitionings. Numbers beside nodes refer to estimated Maximum likelihood bootstrap and Bayesian posterior probability support values. Solid texture boxes indicate the MOTU-partitionings proposed by the ABGD (purple), bPTP-BS (blue) and bPTP-ML (green), the partitionings recognized by phylogenetic (orange), morphology (light blue) criteria, and the final partitioning with species names (brown).

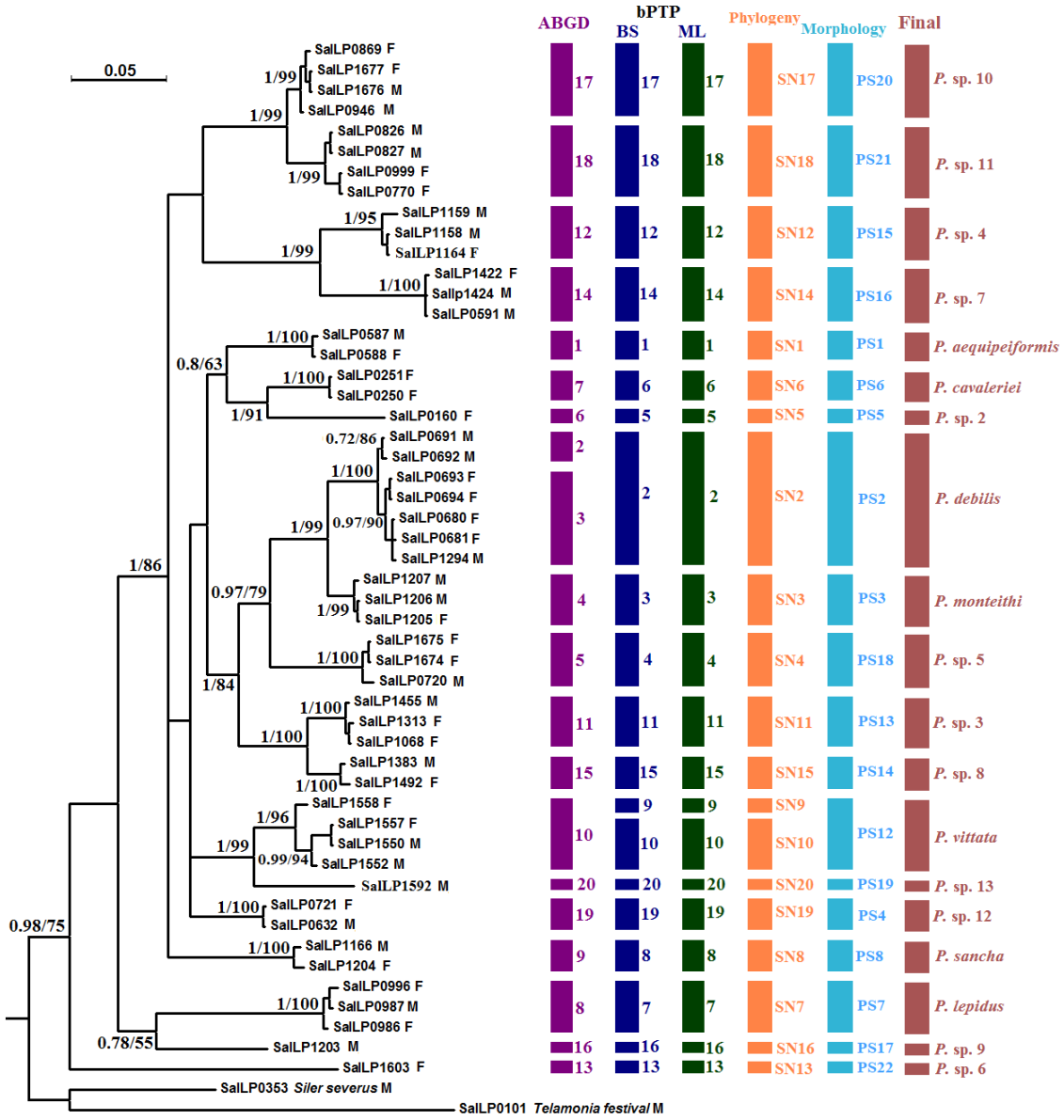

Figure 2.3. Basian phylogenetic tree based on 16S-ND1 dataset, and MOTU-partitionings. Numbers beside nodes refer to estimated Maximum likelihood bootstrap and Bayesian posterior probability support values. Solid texture boxes indicate the MOTU-partitionings proposed by the ABGD (purple), bPTP-BS (blue) and bPTP-ML (green), the partitionings recognized by phylogenetic (orange), morphology (light blue) criteria, and the final partitioning with species names (brown).

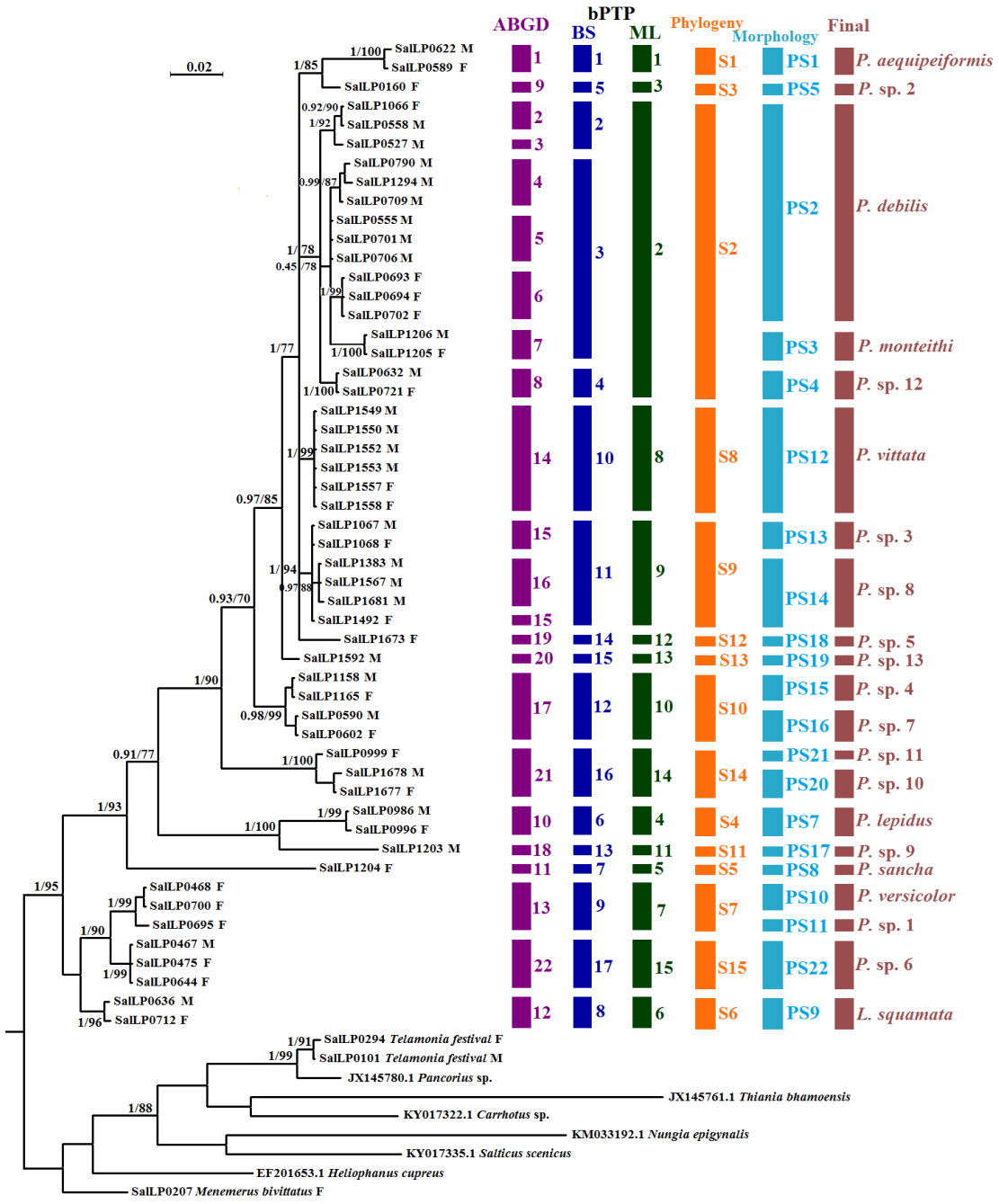

Figure 2.4. Basian phylogenetic tree based on 28S dataset, and MOTU-partitionings. Numbers beside nodes refer to estimated Maximum likelihood bootstrap and Bayesian posterior probability support values. Solid texture boxes indicate the MOTU-partitionings proposed by the ABGD (purple), bPTP-BS (blue) and bPTP-ML (green), the partitionings recognized by phylogenetic (orange), morphology (light blue) criteria, and the final partitioning with species names (brown).

Chapter 3.

PHYLOGENETIC STRUCTURE OF VIETNAMESE PHINTELLA

3.1. Introduction

3.1.1. Intrageneric phylogeny and classification of Salticidae and Phintella

Salticidae, the so-called "jumping spiders", is the most diverse family of the order Araneae, not only richest in the number of described species (Jackson *et al.*, 2001) but also extraordinary diversity in morphology, behavior, and predatory ecology (Jackson, 1982, 1986; Richman, 1992; Jackson & Pollard, 1996; Hedin & Maddison, 2001). Salticidae are found throughout the world, and the group consists of nearly 6,000 described species belonging to 625 genera, holding 13% of all species of spiders (Bodner & Maddison, 2012; World Spider Catalog, 2017).

The origin of the family Salticidae, and the generic-level and higher-level relationships within Salticidae have been intensively studied in recent years (Maddison & Hedin, 2003; Su *et al*., 2007; Maddison *et al*., 2008; Hill and Richman, 2009; Penney, 2010; Bodner & Maddison, 2012; Zhang & Maddison, 2013; Maddison *et al*., 2014; Maddison, 2015; Prószyński, 2016). Hill & Richman (2009) proposed a Late Cretaceous origination of Salticidae, and jumping spiders being derived from one of the other RTA dionychan clades, including Philodromidae, Thomisidae, Miturgidae, Anyphaenidae, Gnaphosidae and related groups. On the other hand, Penney (2010) proposed a Cenozoic origination for Salticidae, a Late Cretaceous origination for jumping spiders cannot be ruled out entirely though.

Maddison (2015) revised the higher classification of Salticidae on the basis of both molecular and morphological information, and divided Salticidae into seven subfamilies: Onomastinae, Asemoneinae, Eupoinae, Lyssomaninae, Spartaeinae, Hisponinae and Salticinae. On the other hand, Prószyński (2016) revised the classification on the basis of the morphology of reproductive organs, and proposed 37 "groups of genera". In contrast to such the generic-level and higher-level phylogenetic

relationship, species-level or species-group-level relationships have been poorly revealed.

The genus *Phintella* is one of the most speciose genera consisting of 61 named species (World Spider Catalog, 2017). Twenty-six species of them were originally described under *Phintella*, and 35 species were transferred mainly from *Chrysilla* Thorell, 1887; *Cosmophasis* Simon, 1901; *Dexippus* Thorell, 1891; *Euophrys* Koch, 1834; *Heliophanus* Koch, 1833; *Icius* Simon, 1876; *Jotus* Koch, 1881; *Maevia* Koch, 1846; *Plexippus* Koch, 1846; *Telamonia* Thorell, 1887; *Thiania* Koch, 1846; and *Viciria* Thorell, 1877 (World Spider Catalog, 2017). On the other hand, five species originally described under *Phintella* were later transferred to *Telamonia* Thorell, 1887, *Chalcoscirtus*, Bertkau, 1880, *Nandicius*, Prószyński, 2016, *Chinattus*, Logunov, 1999 and *Chrysilla*, Thorell, 1887 (World Spider Catalog, 2017). Furthermore, 13 new species were found from Vietnam by integrated taxonomy (Chapter 2).

When we want to describe a new species belonging to such speciose genera, we should examine the type specimens of all of the congeners known from at least the same biogeographic region. Thus the process of describing species (even a single species) is usually time-consuming. However, a partitioning with intrageneric groups may often contribute to speed up the process, because, in practice, we can narrow the range of examining the type specimens.

3.1.2. Purposes of this chapter

The present study aims to reveal whether Vietnamese species of *Phintella* are able to be assigned into multiple clades based on molecular phylogenetic analyses.

3.2. Materials and Methods

Taxon sampling, PCR amplification, sequencing and phylogenetic analyses were as mentioned in Chapter 2. Information on the sequences used in analyses was given in Table 2.1.

3.3. Results

3.3.1. Monophyly of Vietnamese species

A clade consisting of Vietnamese species of *Phintella* was constantly supported by Maximum likelihood and Bayesian inference analyses (bootstrap values = 81% in COI, 75% in 16S-ND1, 95% in 28S; posterior probability values = 1 in COI, 0.98 in 16S-ND1, 1 in 28S; Figs. 3.1–3.6). This clade is hereafter referred to as the VN clade. *Laufeia squamata* recognized by the present integrated taxonomy (Chapter 2) was constantly nested within the VN clade (Figs. 3.1–3.2, 3.5–3.6; 16S-ND1 could not be sequenced for *L. squamata*).

3.3.2. Intrageneric structure seen in phylogenetic trees based on CO1

Within the VN clade (consisting of 20 Vietnamese species of *Phintella*, with the exceptions of *P.* sp. 2 and *P.* sp. 13; Figs. 3.1, 3.2), three clades were recognized: the "*P. debilis* clade" consisting of 14 Vietnamese species, i.e., *P. aequipeiformis, P. cavaleriei, P. debilis, P. monteithi, P. sancha, P. vittata, P.* sp. 3, *P.* sp. 4, *P.* sp. 5, *P.* sp. 7, *P.* sp. 8, *P.* sp. 10, *P.* sp. 11 and *P.* sp. 12 (bootstrap value = 70 %; posterior probability value = 0.96); the "*P. lepidus* clade" consisting of two Vietnamese species, i.e., *P. lepidus* and *P.* sp. 9 (bootstrap value = 99 %; posterior probability value = 1); and the "*P. versicolor* clade" consisting of three species, i.e., *P. versicolor*, *P.* sp. 1 and *P.* sp. 6 (bootstrap value = 96 %; posterior probability value = 1). The clade consisting of *L. squamata* and the *P. versicolor* clade were supported well by the Bayesian inference analysis (posterior probability value = 0.95), but weakly supported by the Maximum likelihood analysis (bootstrap value = 59 %).

3.3.3. Intrageneric structure seen in phylogenetic trees based on 16S-ND1

Within the VN clade (consisting of 19 Vietnamese species, with the exceptions of *L. squamata*, *P. versicolor* and *P.* sp.1; Figs. 3.3, 3.4), the *P. debilis* clade was recognized; *P.* sp. 2 and *P.* sp. 13 of which the CO1 could not be sequenced were included in the *P. debilis* clade (bootstrap value = 86 %; posterior probability value = 1). The *P. lepidus* clade was not supported by Maximum likelihood analysis and Bayesian inference analysis (bootstrap value = 55 %; posterior probability value = 0.78).

3.3.4. Intrageneric structure seen in phylogenetic trees based on 28S

Within the VN clade (consisting of 21 Vietnamese species; Figs. 3.5, 3.6), three clades were recognized: the *P. debilis* clade (excluding *P. sancha*), the *P. lepidus* clade and the *P. versicolor* clade (bootstrap value: ≥ 90%; posterior probability value = 1). *Phintella sancha* was, however, not nested in the *P. debilis* clade, but formed a single sister clade to a clade consisting of the *P. debilis* clade and the *P. lepidus*. The clade consisting of *L. squamata* and the *P. versicolor* clade were not supported by the Maximum likelihood analysis and the Bayesian inference analyses.

3.4. Discussion

3.4.1. Phylogeny of Vietnamese species of the genus Phintella

The VN clade consisting of all Vietnamese species of *Phintella* was constantly supported by Maximum likelihood and Bayesian inference analyses, and *Laufeia squamata* recognized by the present integrated taxonomy (Chapter 2) was constantly nested within the VN clade. Thus *L. squamata* needs to be transferred to the genus *Phintella*. This taxonomic treatment will be done in Chapter 4.

The three clades, i.e., the *P. debilis* clade, the *P. versicolor* clade and the *P. squamata* clade, were recognized by compiling the results of phylogenetic analyses based on COI, 16S-ND1 and 28S. The *P. lepidus* clade was recognized by compiling the results of phylogenetic analyses based on COI and 28S, but was not recognized by the results of phylogenetic analyses based on 16S-ND1. The position of *P. sancha* is unstable, i.e., nested in the *P. debilis* clade, or sister to a clade consisting of the *P. debilis* clade and the *P. lepidus* clade. In the present study, the *P. lepidus* clade and *P. sancha* are tentatively treated as the two independent clades. The morphology of these clades is then compared.

P. debilis clade

Members: *P. aequipeiformis, P. cavaleriei, P. debilis, P. monteithi, P. vittata, P.* sp. 2, *P.* sp. 3, *P.* sp. 4, *P.* sp. 5, *P.* sp. 7, *P.* sp. 8, *P.* sp. 10, *P.* sp. 11, *P.* sp. 12 and *P.* sp. 13.

Male palp: embolus short; bulbus elongated with well-developed posterior lobe; one or two retrolateral tibial apophyses present.

Notes. *Phintella accentifera* and *P. argenteola*, which could not be investigated by molecular phylogenetic analysis because of lack of fresh specimens, are probably placed in this clade based on external morphology of *Male palp.* Among those, *P. argenteola* are proposed as a junior synonym of *P. debilis* (Chapter 4).

***P. sancha* clade**

Member: *P. sancha*.

Male palp: embolus short; bulbus elongated, with well-developed posterior lobe; three retrolateral tibial apophyses present.

Notes. The *P. sancha* clade with three retrolateral tibial apophyses is well distinguished from the *P. debilis* clade with one or two retrolateral tibial apophyses, and from the other clades in which one retrolateral tibial apophysis present.

***P. lepidus* clade**

Members: *P. lepidus* and *P.* sp. 9.

Male palp: embolus rather long (longer than those of the members of *P. debilis* clade); bulbus elongated, with well-developed posterior lobe; one retrolateral tibial apophysis present.

Notes. Embolus of the *P. lepidus* clade is longer than those of the *P. debilis* clade.

***P. versicolor* clade**

Members: *P. versicolor*, *P.* sp. 1 and *P.* sp. 6.

Male palp: embolus long; bulbus elongated; posterior part of bulbus almost round, not forming a well-developed posterior lobe; one retrolateral tibial apophysis present.

Notes. The clade is distinguished well from the *P. debilis* clade, the *P. sancha* clade and the *P. lepidus* clade by its posterior part of bulbus not forming a well-developed posterior lobe.

***P. squamata* clade**

Member: *P. squamata*.

Male palp: embolus long; bulbus short and almost round; posterior part of bulbus not forming a well-developed posterior lobe; one retrolateral tibial apophysis present.

Notes. The *P. squamata* clade is morphologically siminar to the *P. versicolor* clade, and the monophyly of the two clades were supported well by the CO1-based Bayesian inference analysis. The former with short and round bulbus is distinguishable well from the latter with elongated bulbus.

3.4.2. Implications of the intrageneric partitioning based on the present study

The present study revealed that Vietnamese species of *Phintella* were divided into five clades which are distinguishable by the morphology of male palp and phylogenetic analyses (as mentioned above). Because the taxon sampling was biased toward Vietnam, the formal subgenera should not be proposed based on the present result. Nonetheless, the partitioning of the five clades will be a useful working hypothesis for recognizing and describing species of *Phintella* in the Indo–Chinese subregion. Sequences of newly recognized and described species could be combined into the dataset for further phylogenetic analyses of *Phintella*. By considering this positive feedback, I proposed here the five clades as “species groups”.

References

Bertkau P. 1880. Verzeichniss der bisher bei Bonn beobachteten Spinnen. Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande und Westfalens 37: 215–343.

Bodner M. R. & Maddison W. P. 2012. The biogeography and age of salticid spider radiations (Araneae: Salticidae). Molecular Phylogenetics and Evolution 65: 213–240.

Hedin M. C., & Maddison W. P. 2001. A combined molecular approach to phylogeny of the jumping spider subfamily Dendryphantinae (Araneae: Salticidae). Molecular Phylogenetics and Evolution 18(3): 386–403.

Hill D. E. & Richman D. B. 2009. The evolution of jumping spiders (Araneae: Salticidae): a review. Peckhamia,75(1): 1–7.

Jackson R. R., & Harding D. P. 1982. Intraspecific interactions of Holoplatys sp. indet., a New Zealand jumping spider (Araneae: Salticidae). New Zealand Journal of Zoology 9(4): 487–510.

Jackson R. R. 1986. Web building, predatory versatility, and the evolution of the Salticidae. Spiders: Webs, Behavior, and Evolution 232–268.

Jackson R. R., & Pollard S. D. 1996. Predatory behavior of jumping spiders. Annual Review of Entomology 41: 287–308.

Jackson R. R., Pollard S. D., Nelson X. J., Edwards G. B., & Barrion A. T. 2001. Jumping spiders (Araneae: Salticidae) that feed on nectar. Journal of Zoology 255(1): 25–29.

Koch C. L. 1833. Arachniden. In: Herrich-Schäffer, G. A. W. (ed.) Deutschlands Insecten., Heft 119–121.

Koch C. L. 1834. Arachniden. In: Herrich-Schäffer, G. A. W. (ed.) Deutschlands Insecten., Heft 122–127.

Koch C. L. 1846. Die Arachniden. Nürnberg, Dreizehnter Band 1–234, Vierzehnter Band 1–88.

Koch L. 1881. Die Arachniden Australiens. Nürnberg 1: 1213–1271.

Logunov D. V. 1999. Redefinition of the genus *Habrocestoides* Prószyński, 1992, with establishment of a new genus, *Chinattus* gen n. (Araneae: Salticidae). Bulletin of the British Arachnological Society 11: 139–149.

Maddison W. P. & Hedin M. C. 2003. Jumping spider phylogeny (Araneae: Salticidae). Invertebrate Systematics 17: 529–549.

Maddison W. P., Bodner M. R., & Needham K. M. 2008. Salticid spider phylogeny revisited, with the discovery of a large Australasian clade (Araneae: Salticidae). Zootaxa 1893: 49–64.

Maddison W. P., Li, D., Bodner M., Zhang J., Xu, X., Liu Q., & Liu F. 2014. The deep phylogeny of jumping spiders (Araneae, Salticidae). ZooKeys 440: 57.

Maddison W. P. 2015. A phylogenetic classification of jumping spiders (Araneae: Salticidae). Journal of Arachnology 43(3): 231–292.

Penney D. 2010. The evolution of jumping spiders (Araneae: Salticidae): the palaeontological evidence. Peckhamia 81(8): 1–3.

Prószyński J. 2016. Delimitation and description of 19 new genera, a subgenus and a species of Salticidae (Araneae) of the world. Ecologica Montenegrina 7: 4–32.

Prószyński J. 2016. Monograph of the Salticidae (Araneae) of the world 1995–2015. Version October 304th, 2016. Available online at: http://peckhamia.com/salticidae/.

Richman D. B., & Jackson R. R. 1992. A review of the ethology of jumping spiders (Araneae, Salticidae). Bulletin of the British Arachnological Society 9(2): 33–37.

Simon E. 1876. Les arachnides de France. Tome troisième. Roret, Paris, 364 pp., pl. IX–XIII.

Simon E. 1901. Histoire naturelle des araignées. Paris 2: 381–668.

Su K. F., Meier R., Jackson R. R., Harland D. P., & Li D. 2007. Convergent evolution of eye ultrastructure and divergent evolution of vision mediated predatory behaviour in jumping spiders. Journal of Evolutionary Biology 20(4): 1478–1489.

Thorell T. 1887. Viaggio di L. Fea in Birmania e regioni vicine. II. Primo saggio sui ragni birmani. Annali del Museo Civico di Storia Naturale di Genova 25: 5–417.

Thorell T. 1891. Spindlar fran Nikobarerna och andra delar af Sodr a Asien till storre delen insamlade under K. Danska Korvetten Galatheas resa omkring jorden aren 1845–1847. Bihang till Kongl. Svenska vetenskaps-akademiens handlingar 24(2): 1–149.

World Spider Catalog 2017. World Spider Catalog. Natural History Museum Bern. Available at http://wsc.nmbe.ch, version 17.5 (accessed 2017).

Zhang J., Kapli P., Pavlidis P., & Stamatakis A. 2013. A general species delimitation method with applications to phylogenetic placements. Bioinformatics 29(22): 2869–2876.

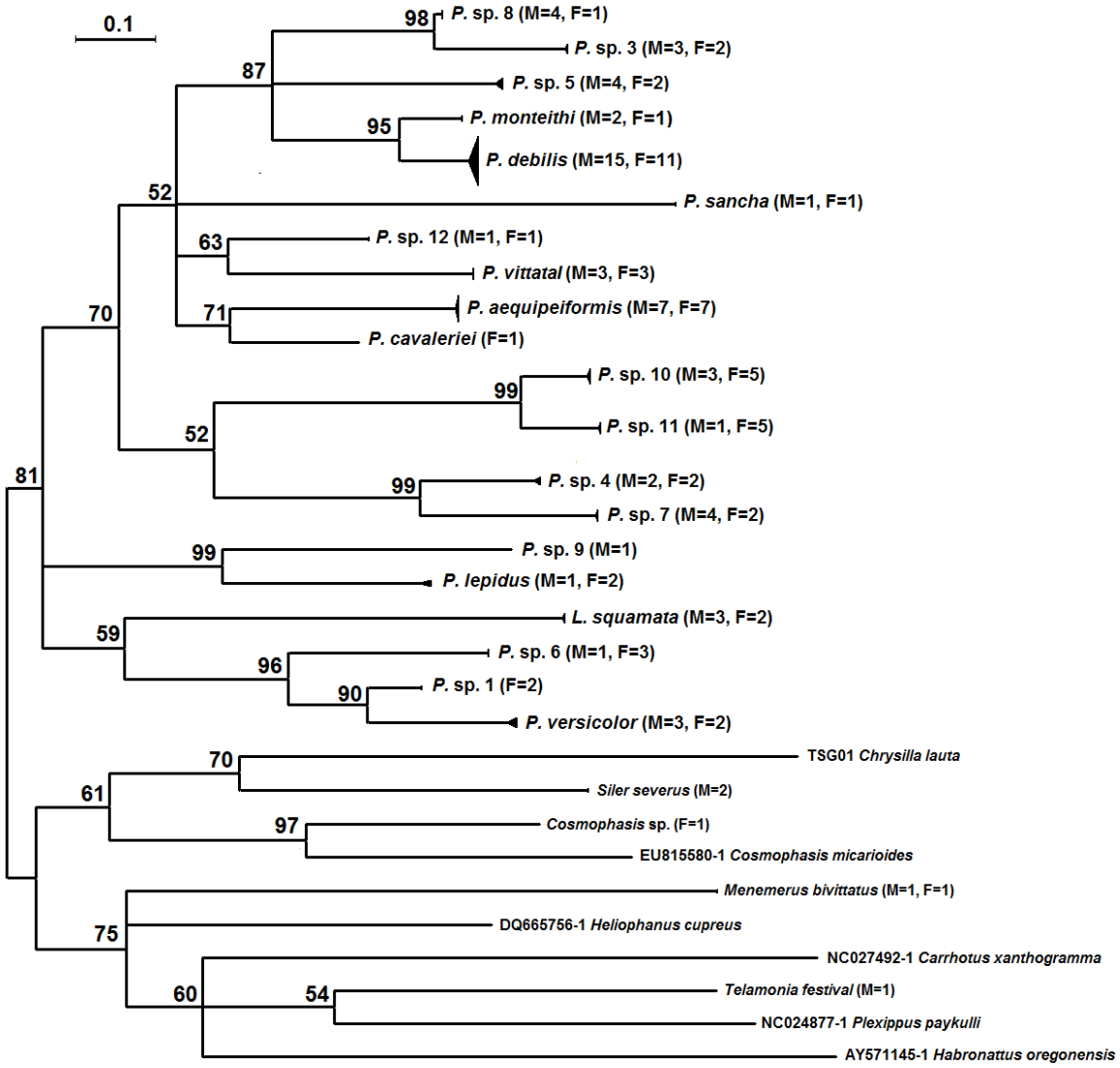

Figure 3.1. Maximum likelihood tree based on the COI dataset. Maximum likelihood bootstrap values are given beside the nodes. The number of samples analysed were given in parentheses after the names of sequences; M: male, F: female.

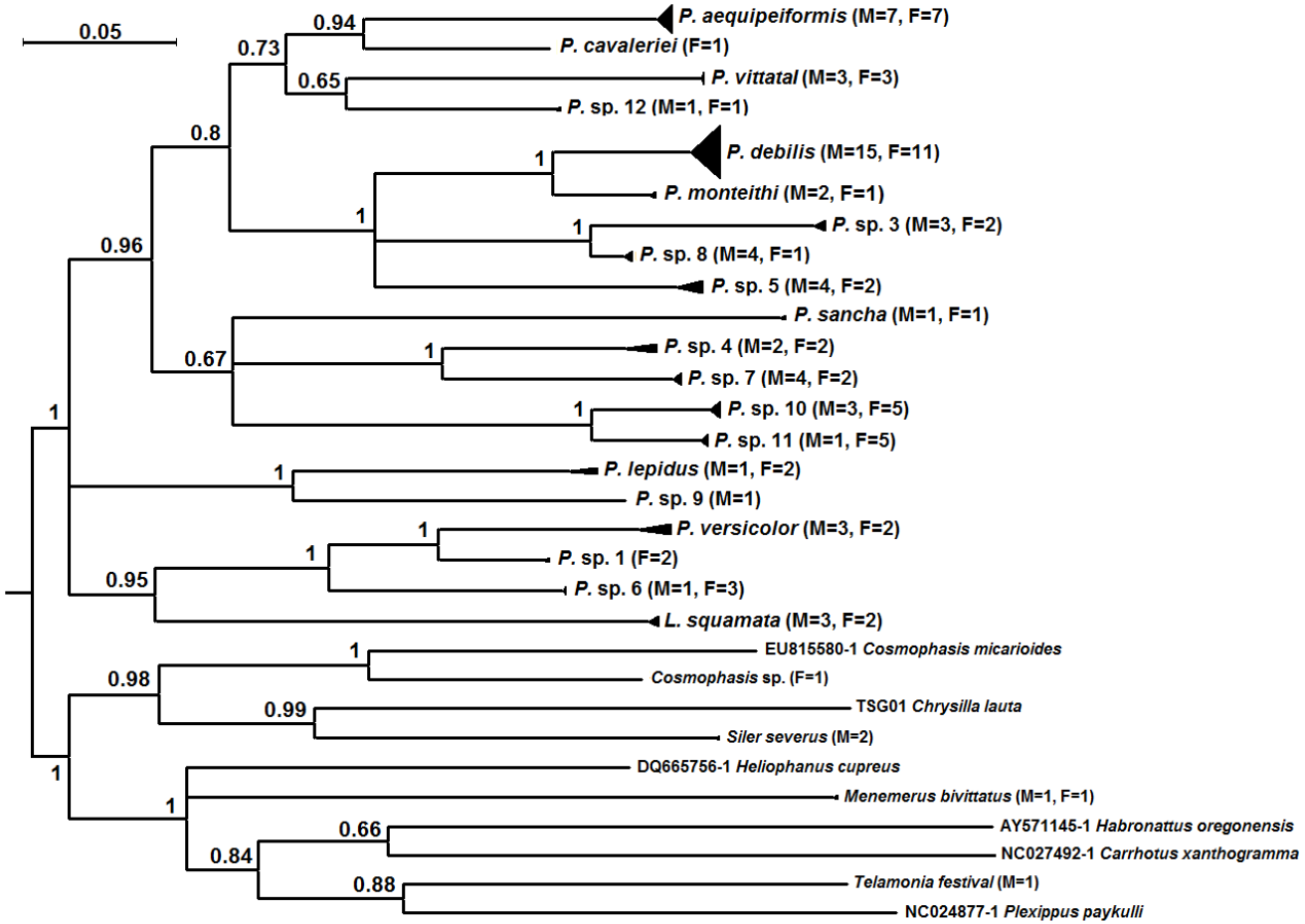

Figure 3.2. Bayesian inference tree based on the COI dataset. Posterior probability values are given beside the nodes. The number of samples analysed were given in parentheses after the names of sequences; M: male, F: female.

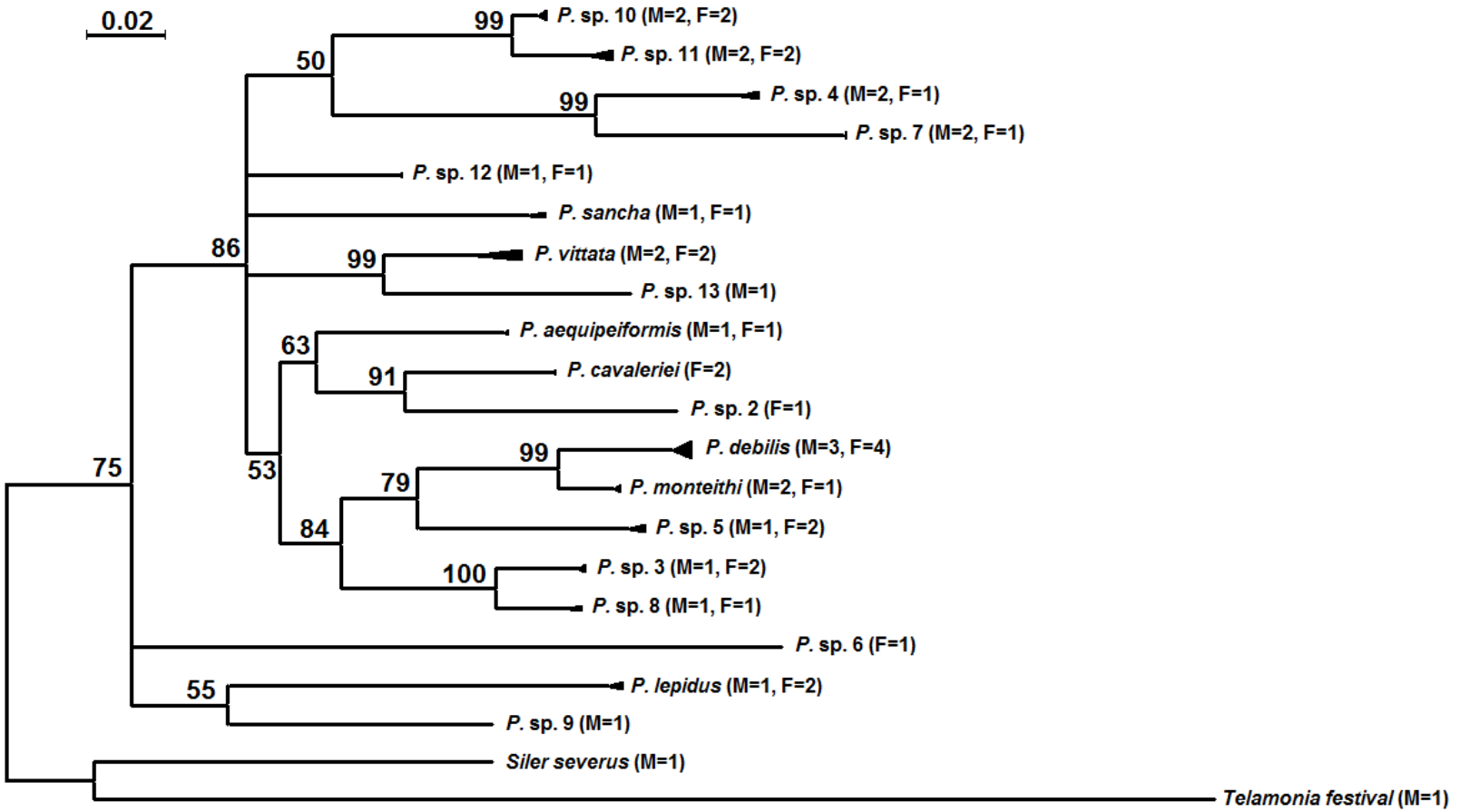

Figure 3.3. Maximum likelihood tree based on the 16S-ND1 dataset. Maximum likelihood bootstrap values are given beside the nodes. The number of samples analysed were given in parentheses after the names of sequences; M: male, F: female.

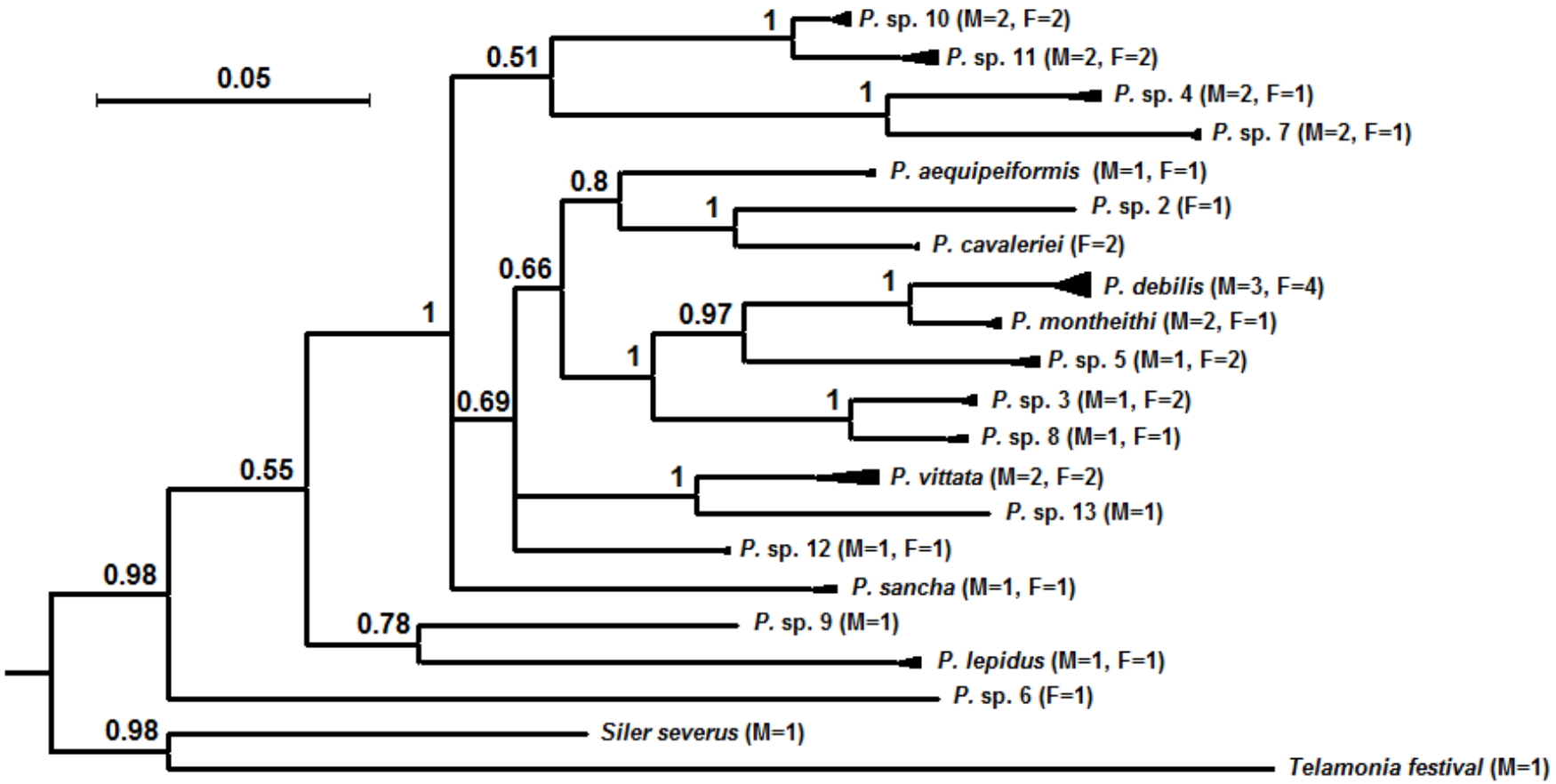

Figure 3.4. Bayesian inference tree based on the 16S-ND1 dataset. Posterior probability values are given beside the nodes. The number of samples analysed were given in parentheses after the names of sequences; M: male, F: female.

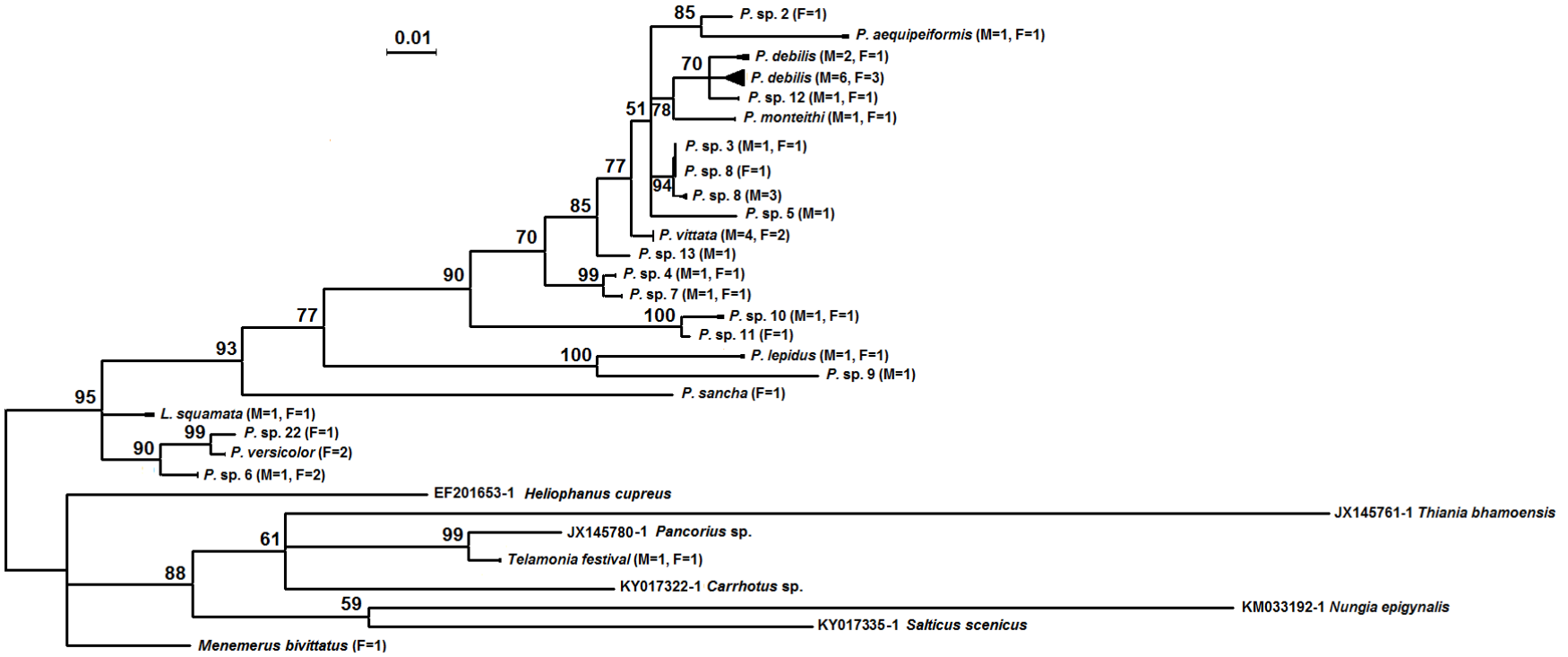

Figure 3.5. Maximum likelihood tree based on the 28S dataset. Maximum likelihood bootstrap values are given beside the nodes. The number of samples analysed were given in parentheses after the names of sequences; M: male, F: female.

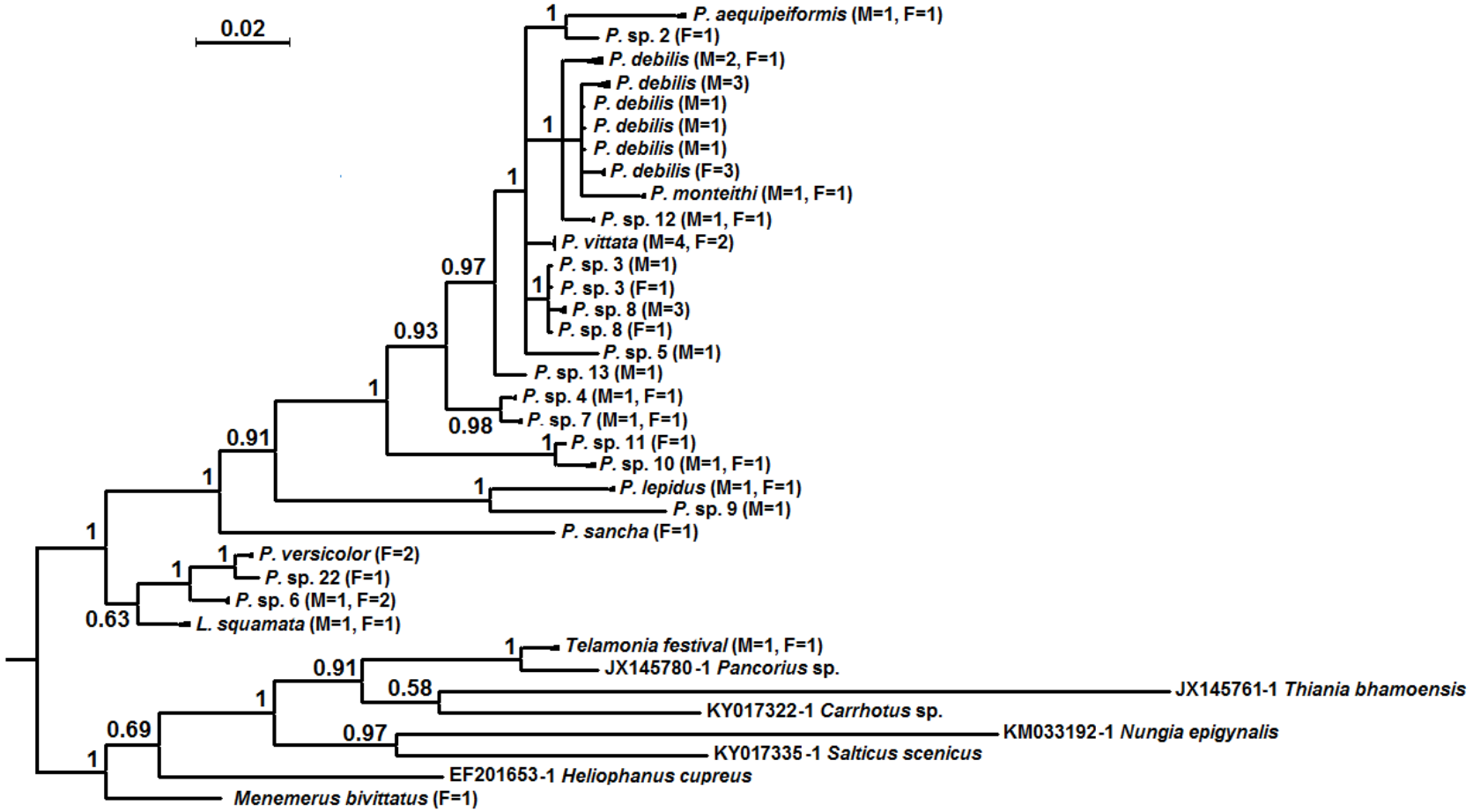

Figure 3.6. Bayesian inference tree based on the 28S dataset. Posterior probability values are given beside the nodes. The number of samples analysed were given in parentheses after the names of sequences; M: male, F: female.

Chapter 4.

REVISION OF VIETNAMESE SPECIES OF THE GENUS *PHINTELLA*

4.1. Introduction

4.1.1. Taxonomic study of the genus Phintella

The genus *Phintella* was established by Strand in Bösenberg and Strand, 1906. Spiders of the genus *Phintella* are defined with a combination of the following characteristics (Fig. 1.1): male and female cephalothorax relatively highly raised; male palpal tegulum with retrolateral bump, usually with posterior lobe; embolus of male palpal usually short, pointed or furcated; tibia of palp with one or more apophyses; insemination ducts of female genitalia variable in length, but usually not twisted; spermatheca usually round (Zabka, 2012; Huang *et al.*, 2015). Maddison (2015) placed the genus *Phintella* in the tribe Chrysillini (Salticinae: Salticoida: Saltafresia) on the basis of both molecular and morphological approaches. Many, but not all, chrysillines have a bump on the palp tegulum which forms a ca. 90˚ degrees in clockwise direction from the base of the embolus in ventral view (left palp in ventral view; Maddison 1987; Maddison & Hedin, 2003; Maddison, 2015).

The genus *Phintella* is one of the most species-rich genera, and 61 species have so far been described from the world (World Spider Catalog, 2017). Among them, 26 species were originally described under *Phintella*, and 35 species were transferred mainly from *Chrysilla* Thorell, 1887, *Cosmophasis* Simon, 1901, *Dexippus* Thorell, 1891, *Euophrys* Koch, 1834, *Heliophanus* Koch, 1833, *Icius* Simon, 1876, *Jotus* Koch, 1881, *Maevia* Koch, 1846, *Plexippus* Koch, 1846, *Telamonia* Thorell, 1887, *Thiania* Koch, 1846, *Viciria* Thorell, 1877 (World Spider Catalog, 2017). On the other hand, five species originally described under *Phintella* were later transferred to *Telamonia* Thorell, 1887, *Chalcoscirtus*, Bertkau, 1880, *Nandicius*, Prószyński, 2016, *Chinattus*, Logunov, 1999 and *Chrysilla*, Thorell, 1887.

4.1.2. Taxonomic study of Vietnamese **Phintella**

The oldest record of the genus *Phintella* in Vietnam is *P. argenteola*. The species was described from Phuc Son, Nghe An province by Simon (1903) as *Telamonia argenteola*, and was later transferred to *Phintella* by Prószyński (1984). After many years since Simon (1903), Zabka (1985) revised salticids of Vietnam, and recorded 10 species of genus *Phintella* from Vietnam, including three new species, *P. aequipeiformis*, *P. lucai* and *P. tibialis*. However, *P. tibialis* was later transferred to *Habrocestoides* by Peng & Xie, 1995, and then transferred to *Chinattus* by Logunov, 1999. Therefore, the following nine species are known from Vietnam: *P. accentifera* (Simom, 1901); *P. aequipeiformis* Zabka, 1985; *P. argenteola* (Simon, 1903); *P. bifurcilinea* (Bösenberg and Strand, 1906); *P. debilis* (Thorell, 1891); *P. lucai* Zabka, 1985; *P. suavis* (Simon, 1885); *P. versicolor* (Koch, 1846); and *P. vittata* (Koch, 1846). These just two previous studies on Vietnamese *Phintella* were based on the materials collected mainly from northern Vietnam. Thus, many species of *Phintella* may remain undiscovered in central and southern Vietnam.

The present integrated taxonomy (the chapter 2) confirmed the conspecificities of *P. aequipeiforms* Zabka, 1985 and *P. lucai* Zabka, 1985, of *P. debilis* (Thorell, 1891) and *P. bifurcilinea* (Bösenberg & Strand, 1906), and of *P. suavis* (Koch, 1846) and *P. vittata* (Koch, 1846), respectively. Furthermore, the present integrated taxonomy reveal the precise male-female complementarity of "*Laufeia squamata* (Zabka, 1985)", and the phylogenetic analyses (the chapter 3) showed that "*L. squamata*" is nested in the clade consisting of Vietnamese species of *Phintella*.

Therefore, in the present chapter, the species-level classification of Vietnamese species of *Phintella* is revised by referring to the results of the chapter 2 and 3, and also by morphologically examining the following two species which are known from Vietnam and its adjacent areas but were unable to be included in the analyses because of lack of fresh specimens suitable for DNA barcoding: *Phintella accentifera* and *P. argenteola*.

4.2. Materials and methods

4.2.1. Sampling and specimen preparation

Materials were collected throughout Vietnam mainly by beating and hand collecting. Each specimen of jumping spider was killed using acetyl acid, and, in fresh condition, a series of images of the body in dorsal view was captured at different focal planes by a Canon EOS Kiss X7i digital camera with a MPE Canon 65 mm len. A multi-focused montage image was produced using Helicon 6.2.2 Pro from the source images. The body was preserved in 75% ethanol for morphological examination.

4.2.2. Morphological examination

Methodology of morphological examination was as described in the chapter 2.

Abbreviations of measurements and indices used in the present study are as follows: BL, body length; CL, carapace length; AL, abdomen length; AW, abdomen width; ALE, anterior lateral eye; AME, anterior median eye; PLE, posterior lateral eye; PME, posterior median eye; ERW, width of anterior/median/posterior eye rows between outer margins of eyes in dorsal view; ALE–PME, distance from anterior margin of ALE to posterior margin of PME, with carapace in dorsal view; ALE–PLE, distance from anterior margin of ALE to posterior margin of PLE, with carapace in dorsal view. All measurements are in millimeters.

Abbreviations of specimen depositories are as follows: HNHM, Hungarian Natural History Museum; MfN, Museum für Naturkunde Berlin; MHNG, Muséum d'histoire naturelle de Genève; MNHN, Muséum national d'Histoire naturelle; NSMT, National Science Museum, Tokyo.

4.3. Taxonomy

4.3.1. Taxonomic remarks and synopsis of Vietnamese **Phintella**

A total of 23 species were recognized from Vietnam, with 13 of these being new species. Three cases of synonymy proposed by the chapter 2 were solved; *P. lucai* Zabka, 1985 synonymized under *P. aequipeiforms* Zabka, 1985; *P. bifurcilinea* (Bösenberg & Strand, 1906) under *P. debilis* (Thorell, 1891); and *P. suavis* (Koch, 1846)

under *P. vittata* (Koch, 1846). The identities of *Phintella accentifera* and *P. argenteola*, which could not be investigated by the present integrated taxonomy approach, were morphologically considered; and *P. argenteola* was synonymized under *P. debilis*. *Phintella accentifera* was confirmed as an independent species. *Laufeia squamta* was transferred to *Phintella*.

Vietnamese species of *Phintella* show the following characteristics: body small (2–6 mm in body length); the male almost as same in size as the female in most species; cephalothorax rather high, with lateral face almost vertical; dorsum of carapace usually with patches of white setae; male palp with short embolus in most species (except for *P. squamata, P. versicolor, P.* sp. 6 and *P.* sp. 9); bulbus with retrolateral bump, usually with lamella outgrowth in anterior part and developed lobe in posterior part; tibia with one or more lateral apophyses; copulatory duct of female genitalia usually not twisted; spermatheca round in most species; fertilization duct connected to anterior dorsum of spermatheca and extending anterolateraly.

4.3.2. Key to Vietnamese species of the genus Phintella

Male

1. Posterior part of bulbus round 2
   Posterior part of bulbus with developed lobe 4
2. Bulbus elongated 3
   Bulbus round ..... *P. squamata*.
3. Embolus of palp curved, extending to direction of 1 o'clock ..... *P. versicolor*.
   Embolus of palp straight, extending to direction of 12 o'clock ..... *P.* sp. 6.
4. Leg I stronger and darker than others 5
   Leg I not stronger than others, and all legs with almost same color pattern 11
5. Palp with one retrolateral tibial apophysis 6
   Palp with more than one retrolateral tibial apophyses 9
6. Abdomen with large longitudinal band on dorsum 7
   Abdomen without large longitudinal band on dorsum ..... *P. lepidus*.
7. Lateral surface of abdomen black or dark gray forming longitudinal black or dark gray streak 8
   Lateral surface of abdomen white forming longitudinal white streak ..... *P.* sp. 9.

8. Retrolateral tooth of chelicera larger than the two prolateral teeth .....*P.* sp. 7.
   One of the two prolateral teeth larger than the retrolateral tooth .....*P.* sp. 4.
9. Palp with two retrolateral tibial apophyses 10
   Palp with three retrolateral tibial apophyses .....*P. sancha*.
10. Chelicera with one large tooth at basal end of fang furrow (Fig. 4.24E).....*P.* sp. 10.
    Chelicera with one small tooth at basal end of fang furrow (Fig. 4.25E) .....*P.* sp. 11.
11. Chelicera with two retrolateral teeth 12
    Chelicera with one retrolateral tooth 14
12. Body mainly covered with metallic setae.....3
    Body not covered with metallic setae..... *P. accentifera*
13. Retrolateral tibial apophysis thin, curved.....*P. vittata*
    Retrolateral tibial apophysis thick, not curved.....*P.* sp.13
14. Retrolateral tooth of chelicera large .....*P.* sp. 3.
    Retrolateral tooth of chelicera small.....15
15. Carapace with one patch of white setae on dorsum (4.22A,B) .....*P.* sp. 8.
    Carapace with more than one patches of white setae on dorsum 16
16. Abdomen with white and black bands of setae running transversally over dorsum ....
    .....*P. aequipeiformis*.
    Abdomen without white and black bands running transversally over dorsum 17
17. Abdomen with two black or gray bands running longitudinally over dorsum.....18
    Abdomen without black or gray band running longitudinally over dorsum 19
18. Dorsum of carapace with cluster of black setae above AME.....*P. monteithi*.
    Dorsum of carapace without cluster of black setae above AME.....*P. debilis*.
19. Posterior dorsum of abdomen yellow.....*P.* sp. 5.
    Posterior dorsum of abdomen dark gray .....*P.* sp. 12.

Female

1. Legs with white patches of setae on dorsum 2
   Legs without white patches of setae on dorsum.....5
2. Abdomen covered with mixture of black and white spots of setae on dorsum 3
   Abdomen not covered with mixture of black and white pots of setae on dorsum 4
3. Copulatory opening toward lateral side of genitalia.....*P. squamata*

Copulatory opening toward anteromedial of genitalia ..... *P.* sp. 1

4. Abdomen manly black, with yellow patches on dorsum.....*P.* sp. 6

   Abdomen with white and black bands running transversally over dorsum....*P.* sp. 12

5. Body covered with metallic setae.....*P. vittata*

   Body not covered with metallic setae.....6

6. Copulatory duct connected to middle part of spermatheca (Fig. 4.1O,Q) ..... *P. aequipeiformis*

   Copulatory duct connected to anterior or posterior part of spermatheca 7

7. Copulatory duct connected to anterior part of spermatheca 8

   Copulatory duct connected to posterior part of spermatheca 15

8. Copulatory opening toward anteriorly.....9

   Copulatory opening toward posteriorly.....14

9. Copulatory duct diameter wider than 1/2 of spermatheca diameter.....10

   Copulatory duct diameter narrower than 1/2 of spermatheca diameter 11

10. Copulatory duct long, about 2 times of spermatheca diameter .....*P.* sp. 5

    Copulatory duct shorter than 2 times of spermatheca diameter .....*P. lepidus.*

11. Lateral surface of carapace with yellowish band, covered with white setae 12

    Lateral surface of carapace without yellowish band ..... *P. cavaleriei*

12. Area behind fovea black.....*P. sancha*

    Area behind fovea yellow or brown 13

13. Middle part of abdomen with yellowish cream band running transversally over dorsum .....*P.* sp. 2

    Middle part of abdomen without yellowish cream band running transversally over dorsum .....*P. versicolor*

14. Abdomen covered with white setae, with yellow patches.....*P.* sp. 8

    Abdomen without yellow patches .....*P. debilis*

15. Body mainly white or yellowish cream, without distinct color patterns.....16

    Body with different color patterns.....17

16. Copulatory duct long, about 2 times of spermatheca diameter .....*P.* sp. 7

    Copulatory duct not much longer than spermatheca diameter .....*P.* sp. 4

17. Copulatory opening located in anterior venter of genitalia.....18

    Copulatory opening located in posterior venter of genitalia .....*P.* sp. 11

18. Dorsum of thoracic part with longitudinal brownish yellow band..... *P. accentifera*
    Dorsum of thoracic part without longitudinal brownish yellow band.....19
19. Copulatory duct diameter wider than 1/3 of spermatheca diameter.....20
    Copulatory duct narrower than 1/3 of spermatheca diameter ..... *P. monteithi*
20. Copulatory duct strongly curved near anterior venter of spermathecae.....*P.* sp. 3
    Copulatory duct not curved .....*P.* sp. 10

4.3.3. Description

Phintella accentifera (Simon, 1901)

(Fig. 4.28)

Telamonia accentifera Simon, 1901a: 548. — Prószyński, 1978: 336, fig. 7.

Phintella accentifera Prószyński, 1984: 156. — Zabka, 1985: 428, figs 430–434, 452. — Xie, 1993: 358, figs 6–7. — Peng *et al.*, 1993: 150, figs 515–517. — Song *et al.*, 1999: 537, figs 307H, 327R.

Type material examined: **Lectotype,** male (designated here), MNHN, 10254, India: Kodaikanal. **Paralectotypes**, 10 males, 22 females and 7 juveniles, same data as in lectotype.

Non-type material examined: Unavailable.

Diagnosis: Dorsum of thoracic part with longitudinal brownish yellow band in both sexes; dorsum of abdomen with three or four white roof-shaped markings at posterior part.

Measurements: *Male* (n=11). BL 4.07–5.30; CL 1.88–2.53; AL 2.08–2.64; AW 1.28–1.83. ERW anterior 1.24–1.55; ERW median 1.16–1.40; ERW posterior 1.23–1.51; ALE–PME 0.39–0.49; ALE–PLE 0.80–1.04.

Female (n=22). 4.14–6.03; CL 1.90–2.15; AL 2.23–3.65; AW 1.55–2.32. ERW anterior 1.32–1.40; ERW median 1.19–1.25; ERW posterior 1.31–1.38; ALE–PME 0.36–0.44; ALE–PLE 0.81–0.91.

Description:

Male body. Carapace reddish brown, with brownish yellow band running longitudinally on thoracic dorsum; with carapace in dorsal view, margin of carapace round, and length and width almost same; lateral surface covered with scale-like setae. Eye field darker than other surfaces of cephalic part; surroundings of anterior eyes and clypeus margin fringed with white setae. Chelicera brown, long and strong; prolateral margin of fang furrow bearing two small teeth basally, retrolateral margin bearing one large tooth and one small basal tooth. Fang long, dark brown, weakly curved in apical part. Maxilla brownish yellow, laterally tinged with black. Labium dark brown, posteriorly tinged with black. Sternum brown yellow. Abdomen gray or dark gray, dorsally with four small brown spots at middle part and three white roof-shaped markings at posterior part. Legs yellowish brown, femur I darker than other segments.

Male palp. Tibia and cymbium dorsally brown. Embolus short, extending to direction of 2 o'clock. Anterior part of bulbus with well-developed retrolateral outgrowth. Posterior lobe of bulbus long and large; tip of lobe extending to posterior margin of tibia in ventral view. Retrolateral tibial apophysis short, thorn-shaped; basal surface of retrolateral tibial apophysis roundly swollen.

Female body. Carapace dorsally dark brown, with brownish yellow band running longitudinally on thoracic dorsum; with carapace in dorsal view, margin of carapace oval, carapace much longer than width. Clypeus and lateral surface of cephalic part yellowish cream, covered with white scale–like setae. Chelicera yellowish brown. Fang short, brown. Maxilla and sternum whitish gray. Labium blackish brown. Abdomen almost same as in male, except for longitudinal white streaks running lateral surfaces. Legs and palp yellow.

Female genitalia. Copulatory openings toward lateral side of genitalia, located close to anterior part of spermatheca at anterior medial part of genitalia. Copulatory ducts little longer than spermatheca diameter, connected to posterior venter of spermatheca, copulatory duct diameter larger than 1/3 of spermatheca diameter. Spermatheca with soybean-shaped. Fertilization ducts connected to anterior dorsum of spermatheca, and extending anterolaterally.

Distribution: Vietnam: Ninh Binh (Zabka, 1985; for details see the Remarks); China (Peng *et al.*, 1993; Song *et al.*, 1999); India (Simon, 1901).

Remarks: *Phintella accentifera* was originally described as a member of *Telamonia* by Simon (1901). The original description of *Phintella accentifera* (Simon, 1901), which were originally described as a member of *Telamonia*, does not give any collection data except for the type locality as "India". I examined two vials deposited in the Simon's collection of MNHM: No. 10254 containing 40 specimens, and No. 20039 containing 5 specimens. The vial No. 10254 contains 40 specimens and a handwritten label with the following information: "10254 *Telam. accentifera es*" and "Kodeikanal". On the other hand, the vial No. 20039 contains 5 specimens and a handwritten label with the following information: "20039 *Telam. accentifera es*" and "Madura (Fubu)". I regarded the specimens in the vial No. 10254 as the syntypes by the following reasons: (1) "*es*" is the sigunature of Eugène Simon (Christine Rollard, pers. com.); (2) the specimens were collected in India (Kodaikanal); (3) no other specimens with information corresponding to the original description were found in the Simon's collection of MNHM. I here designated the lectotype (male) and paralectotypes from the syntypes.

Zabka (1985) recorded and redescribed two females of *P. accentifera* collected from Vietnam. Although I was unable to access and examine his voucher specimens, and also unable to obtain any additional specimens from Vietnam by myself, I reconfirm his identification based on my careful examination of the paralectotype females and of the redescription of *P. accentifera*.

Phintella accentifera is similar to *P. vittata* (Koch, 1846) and *P.* sp. 13 in male chelicera with retrolateral margin of fang furrow bearing one large tooth and one small basal tooth, but distinguished from the latter two by dorsum of thoracic part with longitudinal brownish yellow band in both sexes; dorsum of abdomen with three or four white rooF-shaped markings at posterior part.

***Phintella aequipeiformis* Zabka 1985**

Figs. 4.1, 4.2

Phintella aequipeiformis Zabka, 1985: 427, figs 422–425, 450. —Xie, 1993: 358, figs 8–10. — Peng *et al.*, 1993: 151, figs 518–523. — Song *et al.*, 1999: 537, figs 307I, 328A. — Yin *et al.*, 2012: 1423, fig 775a–f.

Phintella lucai Zabka, 1985: 430, figs 444–446. **Syn. nov**.

Type material examined: *Phintella aequipeiformis,* holotype, male; HNHM, Aranear-5082; Vietnam, Lao Cai, 5km E of town, 200m.a.s.L., beaten from bushes in valley ota creek; 26.XI.1971; leg. Topál-Matsksi; det. Zabka, XI.1981. — *Phintella lucai*, holotype, female; HNHM, Aranear-5102; Vietnam, Yen Bai prov. Luc Yen, 300m.a.s.L., beaten from bushes in forest; 5.XII.1971; leg. Topál-Matsksi; det. Zabka, XI.1981.

Non-type material examined: Vietnam: MHNG; Sal-LP-0531, 1 male; Tuyen Quang Province, Na Hang Nature Reserve; 11.III.2015; leg. Luong & Yamasaki. — MHNG; Sal-LP-0587, 1 male; Sal-LP-0588, 1 female; Sal-LP-0729, 1 female; Ha Tinh Province, Vu Quang National Park; 18.III.2015; leg. Luong & Yamasaki. — NSMT; Sal-LP-0586, 1 male; Sal-LP-0589, 1 female; Ha Tinh Province, Vu Quang National Park; 18.III.2015; leg. Luong & Yamasaki. — IEBR-AR-0272, 2 males; IEBR-AR-0331, 1 female; Ha Tinh Province, Vu Quang National Park; 18.III.2015; leg. Luong & Yamasaki. — IEBR-AR-0382, 1 female; Ha Tinh Province, Vu Quang National Park; 23.III.2015; leg. Luong & Yamasaki. — Sal-LP-0048, 1 female; Quang Binh Province, Phong Nha - Ke Bang National Park; 23.IV.2014; leg. Luong. — Sal-LP-0325, 1 female; Sal-LP-0329, 1 male; Phu Tho Province, Xuan Son National Park; 10.VIII.2014; leg. Luong. — Sal-LP-0490, 1 female; Sal-LP-0491, 1 male; Tuyen Quang Province, Na Hang Nature Reserve; 10.III.2015; leg. Luong & Yamasaki. — Sal-LP-0730, 1 female; Ha Tinh Province, Vu Quang National Park; 18.III.2015; leg. Luong & Yamasaki. — Sal-LP-0622, 1 male; Ha Tinh Province, Vu Quang National Park; 19.III.2015; leg. Luong & Yamasaki. — Sal-LP-0726, 1 female; Sal-LP-0727, 1 female; Sal-LP-0728, 1 female; Ha Tinh Province, Vu Quang National Park; 23.III.2015; leg. Luong & Yamasaki. — Sal-LP-0731, 1 male; Ha Tinh Province, Vu Quang National Park; 24.III.2015; leg. Luong & Yamasaki.

Diagnosis: Markings on abdomen of both sexes characteristic, i.e. one white and two black bands of setae running transversally over dorsum. Spermatheca of female genitalia weakly constricted, and divided into relatively small anterior part and large posterior part.

Measurements: *Male* (n=9). BL 3.32–4.50; CL 1.72–2.25; AL 1.53–2.21; AW 0.94–1.36; ERW anterior 1.28–1.64; ERW median 1.06–1.41; ERW posterior 1.19–1.54; ALE–PME 0.38–0.55; ALE–PLE 0.79–1.09.

Female (n=12). BL 3.24–4.83; CL 1.56–1.97; AL 1.60–2.65; AW 1.21–2.00; ERW anterior 1.28–1.51; ERW median 1.08–1.29; ERW posterior 1.24–1.44; ALE–PME 0.42–0.46; ALE–PLE 0.85–0.86.

Description:

Male body. Carapace mainly black on dorsal surface, yellowish cream tinged with black on lateral surface. AME fringed with whitish gray setae. Dorsum of cephalic part covered with shiny setae; area between PME and PLE covered with white setae forming white patch. Thoracic part of carapace with yellowish cream fin-shaped area behind fovea, covered with white setae. Lateral sides of carapace almost vertical, lateral surface of thoracic part with large yellowish area extending from above coxa II to coxa IV, covered with white setae. Clypeus brown to yellowish brown, sparsely covered with whitish transparent setae. Chelicera long, dorsally pale brown, with two prolateral and one retrolateral teeth at basal end of fang furrow. Fang long, pale brown. Abdomen covered with several kinds of setae; anterior quarter of dorsum covered with transparent setae; middle part of dorsum blackish, with white setae forming one white and two black transversal bands, white band running between black bands; posterior part of dorsum yellowish cream, posterior end black, covered with transparent setae. Legs with a pattern of black and pale yellow; small patches on dorsum of patellae and tibiae covered with white setae.

Male palp. Embolus short and slightly bent, claw-like. Anterior part of bulbus with round retrolateral outgrowth. Posterior part of bulbus with well-developed lobe extending to anterior margin of tibia. Tibia brown or gray, length of tibia shows some variations, from 1/3 to 2/3 the length of cymbium. Retrolateral tibial apophysis short, extending anteriorly.

Female body. Carapace almost as in male; its lower lateral surface pale yellow, lighter than that of male, covered with white setae. Clypeus densely covered with white setae. Chelicera and fang almost as in male, except for shorter chelicera. Abdomen almost as in male, but more rotund. Legs and palp mostly pale yellow.

Female genitalia. Copulatory opening located close to anterior margin of spermatheca, toward anterolateral of genitalia. Copulatory duct curved, shorter than spermatheca diameter; copulatory duct diameter narrower than 1/3 of spermatheca diameter. Spermatheca weakly constricted, divided into relatively small anterior part and large posterior part; connection points with copulatory duct located near weak constriction. Fertilization duct connected to anterior dorsum of spermatheca and extending anterolaterally.

Distribution: Vietnam: Ha Tinh, Lao Cai, Nghe An, Phu Tho, Quang Binh, Thanh Hoa, Tuyen Quang, Yen Bai (Zabka, 1985; the present study); China (Peng *et al.*, 1993; Song *et al.*, 1999; Yin *et al.*, 2012).

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: *Phintella aequipeiformis* shows some variations in the shape of the bulbus and in the length of the palpal tibia, as well as in the shape of the spermatheca. These varieties occur sympatrically. The results from the present integrated taxonomy strongly suggest that all these varieties belong to a single species. The male-female complementarity of *P. aequipeiformis* was also reconfirmed by integrated taxonomy. This species is distinguishable from the other *Phintella* species by the one white and two black bands of setae running transversally over dorsum of abdomen, and by spermatheca of female genitalia, which is weakly constricted, divided into relatively small anterior part and large posterior part.

***Phintella cavaleriei* (Schenkel, 1963)**

Fig. 4.3

Dexippus cavaleriei Schenkel, 1963: 454, f. 258a–e.

Icius cavaleriei Wesolowska, 1981b: 134, f. 18–21. — Song, Yu & Yang, 1982: 210, f. 8–12. — Hu, 1984: 366, f. 382.6–10.

Dexippus cavalierei Brignoli, 1983c: 636.

Phintella cavaleriei Prószyński, 1983b: 6. — Song, 1987: 293, f. 249. — Feng, 1990: 201, f. 176.1–4. — Chen & Gao, 1990: 189, f. 241a–b. — Chen & Zhang, 1991: 293, f. 307.1–4. — Peng *et al.*, 1993: 154, f. 532–539. — Seo, 1995a: 187, f. 16–21. — Song, Chen & Zhu, 1997: 1736, f. 48a–c. — Song, Zhu & Chen, 1999: 538, f. 307M, 308E–F, 328C. — Namkung, 2002: 614, f. 43.58a–c. — Cho & Kim, 2002: 117, f. 51–52, 155–156, 264–265. — Namkung, 2003: 618, f. 43.58a–c. — Lee *et al.*, 2004: 99. — Zhu & Zhang, 2011: 494, f. 359A–D. — Yin *et al.*, 2012: 1428, f. 778a–h. — Kim & Lee, 2014: 109, f. 77A–D.

Type material examined: Not examined.

Non-type material examined: Vietnam: Sal-LP-0250, 1 female; Sal-LP-0251, 1 female; Lao Cai Province, Sapa town; 29.VII.2014; leg. Luong.

Diagnosis: Copulatory duct of female genitalia narrow, about 1/4 of spermatheca diameter, connected to anterior part of round spermatheca.

Measurements: *Female* (n=2). BL 4.86–5.37; CL 1.69–1.97; AL 3.04–3.11; AW 2.02–2.08; ERW anterior 1.27–1.44; ERW median 1.04–1.26; ERW posterior 1.20–1.38; ALE–PME 0.40–0.52; ALE–PLE 0.79–0.94.

Description:

Male. Unknown from Vietnam.

Female body. Carapace dark brown, covered with sparse of white and yellow setae. AME fringed with white and yellowish setae. Clypeus brown. Chelicera and fang brown. Abdomen with white and gray or dark gray patterns on dorsum and lateral surface; posterior end of abdomen with black spot. Legs yellowish cream.

Female genitalia. Copulatory opening located in anterior venter of genitalia, far from anterior margin of spermatheca, toward anteriorly. Copulatory duct longer than spermatheca diameter; copulatory duct diameter about 1/4 of spermatheca diameter; copulatory duct connected to lateral anterior part of spermatheca. Spermathcae round. Fertilization duct connected to anterior dorsum of spermatheca and extending anterolaterally.

Distribution: Vietnam: Lao Cai (the present study); China; Korea.

Habitat: This species was found in secondary forests, on shrubs along forest trails.

Remarks: *Phintella cavaleriei* is distinguishable from the other *Phintella* species by abdomen with white and gray or dark gray patterns on dorsum and lateral surface, and by narrow copulatory duct.

Phintella debilis **(Thorell, 1891)**

Figs. 4.4–4.6

Ictidops pupus Karsch, 1879: 85.

Chrysilla debilis Thorell, 1891: 115.

Telamonia argenteola Simon, 1903b: 731. — Prószyński, 1978: 336, fig. 10. **Syn. nov**.

Telamonia bifurcilinea Bösenberg & Strand, 1906: 331, pl. 9, f. 153; pl. 13, f. 357. — Shinkai, 1969: 46, f. 26–27. — Paik, 1970b: 88, f. 10–14. — Paik, 1978e: 443. — Song, 1980: 206, f. 115a–g. — Hu, 1984: 391, f. 409.1–7.

Phintella typica Bösenberg & Strand, 1906: 333.

Aelurillus pupus Bösenberg & Strand, 1906: 356.

Hasarius crucifer Dönitz & Strand, in Bösenberg & Strand, 1906: 399.

Phintella argenteola Prószyński, 1984: 107. — Zabka, 1985: 427, figs 420–421, 449. **Syn. nov**.

Icius pupus Prószyński, 1973b: 114, f. 44–46. — Song, 1980: 208, f. 116a–c. — Hu, 1984: 368, f. 383.1–3. — Chen & Zhang, 1991: 301, f. 319.

Phintella debilis Zabka, 1985: 425, f. 408–419, 448. — Chen & Zhang, 1991: 292, f. 305.1–3, 306.1–5. — Prószyński, 1992b: 198, f. 141–145. — Song, Zhu & Chen, 1999: 538, f. 307N–O, 308G. — Peng & Li, 2002h: 342, f. 21–25.

Phintella bifurcilinea Prószyński, 1983b: 7, f. 1–11. — Zabka, 1985: 425, f. 403–407, 447. — Yaginuma, 1986a: 232, f. 129.5. — Song, 1987: 307, f. 263. — Bohdanowicz & Prószyński, 1987: 103, f. 184–192. — Matsumoto, 1989: 125, f. 1B, G. — Chikuni, 1989b: 148, f. 11. — Feng, 1990: 200, f. 175.1–3. — Chen & Gao, 1990: 189, f. 240a–c. — Chen & Zhang, 1991: 294, f. 309.1–6. — Song, Zhu & Li, 1993: 885, f. 61A–E.

— Peng *et al.*, 1993: 153, f. 524–531. — Seo, 1995a: 186, f. 9–15. — Song, Chen & Zhu, 1997: 1736, f. 47a–c. — Song, Zhu & Chen, 1999: 538, f. 307K–L, 308C–D, 328B. — Namkung, 2002: 615, f. 43.59a–b. — Cho & Kim, 2002: 117, f. 49–50, 153–154, 262–263. — Kim & Cho, 2002: 122, f. 181–186. — Namkung, 2003: 619, f. 43.59a–b. — Ono, Ikeda & Kono, 2009: 572, f. 136–139. — Zhu & Zhang, 2011: 493, f. 358A–D. — Yin *et al.*, 2012: 1427, f. 777a–h. — Kim & Lee, 2014: 107, f. 76A–E. — Logugov & Jäger, 2015: 359, f. 45–46.

Type material examined: *Phintella argenteola,* holotype, male; MNHM, 22226; Vietnam, Phuc Son; leg. Fruhstorfer.

Non-type material examined: Vietnam: Sal-LP-0526, 1 male; Sal-LP-0527, 1 male; Sal-LP-0529, 1 female; Sal-LP-0555, 1 male; Sal-LP-0556, 1 female; Sal-LP-0588, 1 male; Tuyen Quang Province, Na Hang Natura Reserve; 12.III.2015; leg. Luong & Yamasaki; — Sal-LP-0701, 1 male; Sal-LP-0702, 1 female; Sal-LP-0706, 1 male; Sal-LP-0709, 1 male; Ha Tinh Province, Vu Quang National Park; 23.III.2015; leg. Luong & Yamasaki; — Sal-LP-0860, 1 male; Tay Ninh Province, Lo Go Xa Mat National Park; 17.IX.2015; leg. Luong; Sal-LP-0679, 1 female; Sal-LP-0680, 1 female; Sal-LP-0681, 1 female; Vinh Phuc Province, Me Linh Biodiversity Station; 3.III.2015; leg. Luong.

Diagnosis: Abdomen of both sexes with two black or gray streaks of setae running longitudinally over dorsum and divided by yellow streak; anterior part of the yellow streak with black patch. Copulatory duct of female genitalia curved, located in anterior venter of genitalia; copulatory opening toward posteriorly.

Measurements: *Male* (n=7). BL 2.92–3.52; CL 1.50–1.79; AL 1.32–1.70, AW 0.87–0.99; ERW anterior 1.10–1.34; ERW median 0.94–1.08; ERW posterior 1.06–1.21; ALE–PME 0.39–0.46; ALE–PLE 0.74.91.

Female (n=6). BL 3.38–3.60; CL 1.31–1.43; AL 1.89–2.12, AW 0.99–1.33; ERW anterior 1.05–1.13; ERW median 0.88–0.96; ERW posterior 1.03–1.09; ALE–PME 0.35–0.37; ALE–PLE 0.76–0.78.

Description:

Male body. Carapace black or dark brown, covered with black setae. Carapace with six to seven white patches of setae on dorsum, three or four in cephalic and three in thoracic part. Lateral sides of carapace almost vertical; lateral surface dark brown. Clypeus brown with sparse white setae. AME fringed with whitish gray setae. Chelicera dorsally brown, with two prolateral and one retrolateral teeth. Fang brown. Abdomen yellow or yellowish cream, with two black or gray streaks of setae running longitudinally over the dorsum and divided by yellow field; anterior part of the yellow field with black patch; posterior part of the yellow field covered with white setae forming white patch. Lateral surface of abdomen with longitudinal yellow streak. Legs with yellowish cream or yellowish brown metatarsi and tarsi; others segments black, except for brown or brownish yellow leg IV; patellae and tibia of legs I, II, III with white setae patch on dorsum.

Male palp. Embolus short and slightly bent, prolateral side of embolus sometime swelling forming a small tooth-shaped outgrowth. Anterior part of bulbus with flatky retrolateral outgrowth. Posterior lobe of bulbus moderately developed, tip of lobe extending to anterior margin or middle part of tibia in ventral view. Tibia dark brown or dark gray, short, about 1/3 the length of cymbium. Retrolateral tibial apophysis short, extending anteriorly.

Female body. Carapace black or dark brown, covered with mixture of black and white setae. Anterior part of carapace with transversal brown band on dorsum, covered with white setae. Lateral sides of carapace vertical, lateral surface mainly dark brown. Clypeus dark brown. Chelicera short, dorsally gray. Fang short, brown. Abdomen almost similar as in male, but without white patches of setae on dorsum. Legs yellow or yellowish cream.

Female genitalia. Copulatory opening located in anterior venter of genitalia, close or far from anterior part of spermatheca, toward posteriorly. Copulatory duct curved, connected to anterior venter of spermatheca; copulatory duct longer than spermatheca diameter; copulatory duct diameter narrower than 1/3 of spermatheca diameter. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Daklak, Gia Lai, Hai Phong, Hanoi, Ha Tinh, Kien Giang; Lao Cai, Ninh Binh, Nghe An, Phu Tho, Quang Binh, Quang Nam, Quang Tri, Tay Ninh, Thanh Hoa, Tuyen Quang, Vinh Phuc, Yen Bai (Simon, 1903; Zabka, 1985; the present study); India to Taiwan; Java; China; Korea; Japan.

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: *Phintella debilis* shows some variations in the length of male chelicera. The results from the present integrated taxonomy strongly suggest that all these varieties belong to a single species. The conspecificity of *P. debilis* and *P. bifurcilinea* and the male-female complementarity of *P. debilis* were also confirmed by integrated taxonomy. *P. argenteoloa* is proposed here as a synonym of *P. debilis* through morphology approach. This species is distinguishable from the other *Phintella* species by abdomen with two black or gray streaks of setae running longitudinally over the dorsum and divided by yellow streak; anterior part of the yellow streak with black patch.

Phintella lepidus Cao & Lee, 2016

Fig. 4.7

Phintella lepidus Cao & Lee in Cao, Lee & Zabka, 2016: 88, f. 32A–D, 33A–F.

Type material examined: Not examined.

Non-type material examined: Vietnam: Sal-LP-0836, 1 male; Sal-LP-0929, 1 female; Sal-LP-0957, 1 female; Sal-LP-0986, 1 female; Sal-LP-0987, 1 female; Tay Ninh Province, Lo Go Xa Mat National Park; 26.IX.2015; leg. Luong; — Sal-LP-0996, 1 female; Kien Giang Province, Phu Quoc National Park; 11.IX.2015; leg. Luong & Yamasaki.

Diagnosis: Embolus of male palp large, claw-shaped; anterior part of bulbus with well-developed retrolateral outgrowth extending anteriorly. Copulatory duct of female genitalia large, about 2/3 of spermatheca diameter.

Measurements: *Male* (n=1). BL 3.64; CL 1.97; AL 1.50, AW 0.91; ERW anterior 1.45; ERW median 1.27; ERW posterior 1.41; ALE–PME 0.41; ALE–PLE 0.89.

Female (n=4). BL 3.25–4.17; CL 1.61–1.71; AL 1.52–2.22, AW 1.03–1.65; ERW anterior 1.26–1.27; ERW median 1.10–1.16; ERW posterior 1.23–1.30; ALE–PME 0.36–0.40; ALE–PLE 0.83–0.87.

Description:

Male body. Carapace dark brown, covered with black setae. Surrounding PME covered with white setae forming white patch. Thoracic part of carapace with one large and two small white patches of setae. Lateral side of carapace almost vertical; lateral surface with large yellow band covered with white setae, extending from coxa II to coxa IV. Clypeus yellow, covered with white setae. Chelicera dark brown, dorsum with two small teeth; prolateral margin of fang furrow bearing two small teeth; retrolateral margin with one small tooth. Fang brownish short, short. Abdomen narrow, almost yellow; anterior part of abdomen on dorsum covered with white setae forming white band; upper and lower margins of this white band tinged with black setae; posterior part of abdomen with two small white and one large black patches of setae on dorsum; lateral surface with white patch located between two black patches of setae in middle part, and one white patch of setae in posterior part of abdomen. Legs yellowish cream, except for black femur, patella and tibia of leg I; leg I much stronger than others.

Male palp. Embolus large, claw-shaped, extending to direction of 1 o'clock. Anterior part of bulbus with well-developed retrolateral outgrowth, extending anteriorly. Posterior lobe of bulbus develop; tip of lobe extending to anterior margin of tibia in ventral view. Tibia yellowish cream, short, about 1/3 the length of cymbium. Retrolateral tibial apophysis straight, short, extending anteriorly.

Female body. Carapace brown, mainly covered with black setae. Area between PME and PLE covered with white setae forming white patch. Thoracic part of carapace with transversal yellow band covered with white setae. Lateral side of carapace vertical; anterior part of lateral surface with yellow patch covered with white setae; posterior part with large yellow band covered with white setae, extending from over coxa II to coxa IV. Clypeus brown. Chelicera and fang dorsally brownish yellow. Abdomen wider than that of in male; dorsum of abdomen yellow, mainly covered with black setae. Anterior part of abdomen with two small white patches of setae on dorsum; middle part with two white patches of setae on dorsum and one white patch of setae on lateral surface;

posterior part of abdomen yellow, posterior end with four small white patches and one black patch on dorsum. Legs yellow.

Female genitalia. Copulatory opening located in anterior venter of genitalia, far from anterior margin of spermatheca, toward anterolaterally. Copulatory duct connected to anterior venter of spermatheca; copulatory duct length almost same spermatheca diameter; copulatory duct diameter about 2/3 of spermatheca diameter. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, and extending anterolaterally.

Distribution: Vietnam: Kien Giang, Tay Ninh (the present study); China.

Habitat: This species was found in secondary forests, on shrubs along forest edges.

Remarks: The male-female complementarity of *Phintella lepidus* was reconfirmed by the present integrated taxonomy. This species is distinguishable from the other *Phintella* species by large, claw-shaped embolus; retrolateral outgrowth of bulbus extending anteriorly; and by large and short copulatory duct.

***Phintella monteithi* Zabka, 2012**

Fig. 4.8

Phintella monteithi Zabka, 2012: 63, f. 8–18.

Type material examined: Not examined.

Non-type material examined: Vietnam: Sal-LP-1205, 1 female; Sal-LP-1206, 1 male; Sal-LP-1207, 1 male; Sal-LP-1208, 1 male; Daklak province, Chu Yang Sin National Park; 10.III.2016; leg. Luong.

Diagnosis: Carapace of male with cluster of black setae above AME; carapace of female with white band of setae above anterior eyes on dorsum.

Measurements: *Male* (n=3). BL 2.38–2.49; CL 1.34–1.37; AL 1.03–1.11, AW 0.64–0.64; ERW anterior 1.00–1.02; ERW median 0.80–0.84; ERW posterior 0.94–0.95; ALE–PME 0.32–0.35; ALE–PLE 0.66–0.67.

Female (n=1). BL 2.55; CL 1.31; AL 1.20, AW 0.86; ERW anterior 0.96; ERW median 0.80; ERW posterior 0.90; ALE–PME 0.31; ALE–PLE 0.65.

Description:

Male body. Carapace dark brown. Anterior part of carapace with two small and one large patches of white setae on dorsum. Surrounding PME and fovea covered with white setae forming white patch. Thoracic part of carapace with three patches of white setae on dorsum. Lateral sides vertical; lateral surface brownish yellow, covered with white setae. Surrounding AME fringed with white setae. Clypeus dark gray with corved with white setae. Chelicera brown, dorsum with gray band; anterior part of chelicerae on dorsum covered with white setae; prolateral margin of fang furrow bearing two small teeth; retrolateral margin with one small tooth. Fang short, brown. Abdomen mainly yellow, covered with brown yellow setae; two black streaks running longitudinally over dorsum of abdomen. Anterior part of abdomen with white band of setae on dorsum; middle part with one white patch of setae located between the two longitudinal black streaks. Legs white band of setae on dorsum of patella, tibia and metatarsi.

Male palp. Embolus extending to direction of 1 o'clock. Anterior part of bulbus with developed retrolateral outgrowth. Posterior lobe of bulbus developed, tip of lobe extending to middle part of tibia. Tibia short, about 1/3 the length of cymbium. Retrolateral tibial apophysis slightly curved, extending anteriorly.

Female body. Carapace brown, mainly covered with black setae. Anterior part of carapace with yellow band covered with white setae on dorsum. Area between PME and PLE covered with white setae forming white patch. Thoracic part with large yellow band covered with white setae on dorsum. Lateral side vertical; lateral surface yellowish gray anteriorly; posterior part with yellow band covered with white setae running from coxa I to coxa IV. Clypeus gray. Chelicera gray on dorsum. Fang short, brown. Abdomen mainly gray; anterior part of abdomen with white band of setae; middle part of abdomen with three white patches of seta; posterior end of abdomen with two white patches of setae. Legs yellowish cream.

Female genitalia. Copulatory opening located in anterior venter of genitalia, far from anterior part of spermatheca, toward anterolateral of genitalia. Copulatory duct connected to posterior venter of spermatheca; copulatory duct length not much longer than spermatheca diameter; copulatory duct diameter narrower than 1/3 of spermatheca

diameter. Spermatheca with posterior part flat. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Daklak (the present study); Queensland.

Habitat: This species was found on leaves of shrubs and trees in dipterocarp forests in dry season.

Remarks: The male-female complementarity of *Phintella monteithi* was newly confirmed by the present integrated taxonomy. The male of this species is morphologically similar to those of in *P. debilis* (Thorell, 1891), but distinguishable by cluster of black setae above AME on dorsum of carapace.

Phintella sancha Cao & Lee, 2016

Fig. 4.9

Phintella sancha Cao & Lee in Cao, Lee & Zabka, 2016: 91, f. 34A–D, 35A–B.

Type material examined: Not examined.

Non-type material examined: Vietnam: Sal-LP-1166, 1 male; Sal-LP-1204, 1 female; Daklak province, Chu Yang Sin National Park; 10.III.2016; leg. Luong.

Diagnosis: Abdomen of male with black streak running longitudinally over dorsum. Male palp with thin, claw-shaped embolus; anterior part of bulbus with well-developed lamella outgrowth, extending anteriorly; three retrolateral tibial apophyses. Female body mainly covered with white setae.

Measurements: *Male* (n=1). BL 3.12; CL 1.55; AL 1.51, AW 0.80; ERW anterior 1.08; ERW median 0.92; ERW posterior 1.07; ALE–PME 0.27; ALE–PLE 0.66.

Female (n=1). BL 2.93; CL 1.35; AL 1.52, AW 0.87; ERW anterior 0.99; ERW median 0.90; ERW posterior 0.98; ALE–PME 0.31; ALE–PLE 0.66.

Description:

Male body. Carapace dark brown, covered with yellow setae. Dorsum of carapace with black band running longitudinally from fovea to posterior end of thorax. Lateral side of carapace vertical; lateral surface with yellow streak covered with white setae running

longitudinally from lateral margin of AME to posterior end of thorax. Clypeus brown, covered with white setae. Chelicera brown, short; anterior part of chelicera covered with white setae; prolateral margin of fang furrow bearing two small teeth; retrolateral margin with one large tooth. Fang short, brown. Abdomen elongated, narrow, covered with yellowish cream setae, with black streak of setae running longitudinally over dorsum. Legs yellowish cream, except for black femur and tibia of leg I; leg I stronger than others.

Male palp. Embolus thin, claw-shaped. Anterior part of bulbus with well-developed lamella outgrowth, extending anteriorly. Posterior lobe of bulbus developed, posterior end of lobe extending to middle part of tibia in prolateral side on ventral view. Tibia short, about 1/3 the length of cymbium. Tibia bearing three retrolateral tibial apophyses, two of those extending to anterior venter of bulbus, the other extending to anterior dorsum of cymbium.

Female body. Carapace covered with white setae; cephalic part yellow brown on dorsum; surrounding of eyes black. Thoracic part of carapace gray on dorsum. Lateral side of carapace vertical; lateral surface yellow, covered with white setae. Clypeus brown yellow, covered with white setae. Chelicera brown yellow, with black band on dorsum. Fang brown. Abdomen covered with white setae; with black streak running longitudinally from anterior to middle part, and black streak running transversally in posterior part of abdomen on dorsum. Lateral surface of abdomen with black spots or patches of setae. Legs yellowish cream.

Female genitalia. Copulatory opening toward anterolateral of genitalia, located far from spermatheca at anterior venter of genitalia. Copulatory duct not much longer than spermatheca diameter, connected to anterior venter of spermatheca; copulatory duct diameter about 1/3 the length of the spermatheca diameter. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Daklak (the present study); China.

Habitat: This species was found in secondary forests, on shrubs along forest trail.

Remarks: The male-female complementarity of *Phintella sancha* was newly confirmed by the present integrated taxonomy. This species is morphologically similar *P.*

versicolor (Koch, 1846) in male abdomen with black streak of setae running longitudinally over dorsum, but distinguishable from the latter by dorsum of carapace of male mainly covered with yellow setae, with black band running longitudinally from fovea to posterior end of thorax.

***Phintella squamata* (Zabka, 1985)**

Fig. 4.10

Lechia squamata Zabka, 1985: 236, f. 259–262. — Song & Chai, 1991: 20, f. 9A–B. — Song, Zhu & Chen, 1999: 533, f. 302G–H.

Laufeia squamata Logunov & Jäger, 2015: 355, f. 33–39

Type material examined: Not examined.

Non-type material examined: Vietnam: Sal-LP-0536, 1 male; Sal-LP-0568, 1 female; Tuyen Quang Province, Na Hang Natura Reserve; 11.III.2015; leg. Luong & Yamasaki; — Sal-LP-0636, 1 male; Sal-LP-0637, 1 male; Sal-LP-0640, 1 male; Sal-LP-0711, 1 female; Sal-LP-0712, 1 female; IEBR-AR-0357, 11 males; IEBR-AR-0379, 3 males, 11 females; Ha Tinh Province, Vu Quang National Park; 19.III.2015; leg. Luong & Yamasaki.

Diagnosis: Carapace of male with longitudinal yellow band of setae on dorsum; abdomen with large black band running longitudinally over dorsum. Bulbus of male palp almost round. Female body covered with mixture of black and white spots of setae.

Measurements: *Male* (n=18). BL 5.43–5.98; CL 2.30–2.69; AL 2.983.27, AW 1.39–1.52; ERW anterior 1.53–1.71; ERW median 1.34–1.47; ERW posterior 1.36–1.60; ALE–PME 0.43–0.59; ALE–PLE 1.04–1.05.

Female (n=14). BL 4.30–5.50; CL 1.97–2.50 AL 2.23–2.87, AW 1.53–2.03; ERW anterior 1.28–1.58; ERW median 1.18–1.45; ERW posterior 1.29–1.54; ALE–PME 0.37–0.48; ALE–PLE 0.86–1.19.

Description:

Male body. Carapace dark gray or dark brown on dorsum, covered with black setae. Dorsum of carapace with longitudinal yellow band of setae. Lateral side almost vertical,

lateral surface with longitudinal yellow band, covered with white setae. Clypeus black, with cluster of white setae. Chelicera black on dorsum, chelicera with two prolateral and one retrolateral teeth. Fang short, brown. Abdomen with large black band running longitudinally over dorsum located between the two yellow streaks; lateral margin of the yellow streak on lateral surface black. Legs II, III, IV yellowish cream; palella, tibia and metatarsi coverd with white setae on dorsum. Leg IV black (except for yellowish cream metatarsi, tarsi and anterior part of tibia on dorsum, covered with white setae), stronger than others.

Male palp. Embolus long and thin, extending to direction of 1 o'clock. Bulbus almost round, without retrolateral outgrowth and posterior lobe. Retrolateral apophysis long, extending anteriorly.

Female body. Carapace yellowish brown, covered with white setae and sparse of black setae. Lateral side vertical, lateral side brownish yellow, covered with white setae. Clypeus brownish yellow, covered with white setae. Chelicera and fang short, brown. Abdomen white or yellowish cream, covered with mixture of black and white spots of setae on dorsum and lateral surface. Legs with segments yellowish cream, covered with white setae, surrounding joints dark gray.

Female genitalia. Copulatory opening located far from anterior margin of spermatheca at anterior venter of genitalia, toward lateral side of genitalia. Copulatory duct shorter than spermatheca diameter, connected to anterior part of spermatheca; copulatory duct diameter narrower than 1/4 of spermatheca diameter. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Hanoi, Ha Tinh, Phu Tho, Thanh Hoa, Tuyen Quang, Vinh Phuc (Zabka, 1985; the present study); China.

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *Phintella squamata* was newly confirmed by the present integrated taxonomy. This species is morphologically similar *P. versicolor* (Koch, 1846) and *P. sancha* Cao & Lee, 2016 in male abdomen with large black band running longitudinally over dorsum, but distinguishable from the latter two by the pattern of carapace with longitudinal yellow streak of setae on dorsum.

Phintella versicolor (Koch, 1846)

Fig. 4.11

Plexippus versicolor Koch, 1846: 103, f. 1165.

Maevia picta Koch, 1846: 72, f. 1328.

Attus versicolor Walckenaer, 1847a: 426.

Chrysilla picta Thorell, 1891: 117. — Workman & Workman, 1894: 10, pl. 10.

Chrysilla versicolor Simon, 1901a: 544. — Prószyński, 1973b: 98, f. 1–7. — Yaginuma, 1977c: 398. — Song, 1982a: 102. — Zabka, 1985: 211, f. 83–96.

Jotus munitus Bösenberg & Strand, 1906: 334, pl. 14, f. 374, 392. — Strand, 1907b: 569. — Yaginuma, 1955c: 14. — Yaginuma, 1960: 107, f. 89.5. — Lee, 1966: 75, f. 28d–f. — Yaginuma, 1971: 107, f. 89.5. — Yin & Wang, 1979: 32, f. 13A–E. — Hu, 1984: 370, f. 386.1–6.

Chira albiocciput Bösenberg & Strand, 1906: 366, pl. 13, f. 311.

Aelurillus dimorphus Dönitz & Strand, in Bösenberg & Strand, 1906: 398, pl. 9, f. 125–126. — Saito, 1959: 147, f. 203a–e.

Dexippus davidi Schenkel, 1963: 446, f. 255a–e.

Dexippus tschekiangensis Schenkel, 1963: 449, f. 256a–e. — Wesolowska, 1981b: 135, f. 27–30.

Icius munitus Wesolowska, 1981a: 59, f. 34–36.

Icius davidi Wesolowska, 1981b: 135, f. 22–26.

Phintella davidi Prószyński, 1983b: 6.

Phintella tschekiangensis Prószyński, 1983b: 7.

Phintella caprina Prószyński, 1984a: 155, 170.

Phintella versicolor Prószyński, 1983a: 44, f. 3. — Prószyński, 1983b: 6, f. 17. — Yaginuma, 1986a: 231, f. 129.1. — Song, 1987: 288, f. 245. — Maddison, 1987: 103, f. 7–8. — Prószyński, 1987: 152, 161. — Bohdanowicz & Prószyński, 1987: 113, f. 210–

213, 216–221. — Matsumoto, 1989: 125, f. 1E, J. — Chikuni, 1989b: 149, f. 12. — Feng, 1990: 202, f. 177.1–4. — Chen & Gao, 1990: 191, f. 243a–b. — Chen & Zhang, 1991: 290, f. 303.1–5. — Peng *et al.*, 1993: 162, f. 569–576. — Zhao, 1993: 411, f. 212a–c. — Maddison, 1996: 330, f. 17. — Song, Chen & Zhu, 1997: 1738, f. 50a–c. — Song, Zhu & Chen, 1999: 539, f. 308O–P, 309F-G, 328E–F. — Hu, 2001: 403, f. 256.1–3. — Namkung, 2002: 616, f. 43.60a–c. — Cho & Kim, 2002: 120, f. 58, 163–164, 272–273. — Namkung, 2003: 620, f. 43.60a–c. — Ono, Ikeda & Kono, 2009: 572, f. 140–143. — Zhu & Zhang, 2011: 497, f. 362A–D. — Yin *et al.*, 2012: 1429, f. 779a–h.

Type material examined: Not examined.

Non-type material examined: Vietnam: Sal-LP-0204, 1 male; Hai Phong Province, Bach Long Vi island; 9.VII.2014; leg. Luong; — Sal-LP-0271, 1 male; Lao Cai Province, Sapa town; 29.VII.2014; leg. Luong; Sal-LP-0468, 1 female; Vinh Phuc Province, Me Linh Biodiversity Station; 3.III.2015; leg. Luong; — Sal-LP-0553, 1 female; Tuyen Quang Province, Na Hang Natura Reserve; 12.III.2015; leg. Luong & Yamasaki; — Sal-LP-0553, 1 female; Hanoi city, Ba Vi district; 22.II.2015; leg. Luong. — Sal-LP-0796, 1 female; Sal-LP-0812, 1 male; Sal-LP-0813, 1 female; Sal-LP-0820, 1 male; Kien Giang Province, Phu Quoc National Park; 12.IX.2015; leg. Luong & Yamasaki.

Diagnosis: Male palp with long embolus; posterior part of bulbus round. Copulatory opening of female genitalia toward anteromedial of genitalia.

Measurements: *Male* (n=4). BL 4.54–7.06; CL 2.02–2.90; AL 2.32–3.78, AW 1.12–1.71; ERW anterior 1.31–1.77; ERW median 1.12–1.55; ERW posterior 1.31–1.67; ALE–PME 0.40–0.59; ALE–PLE 0.90–1.26.

Female (n=5). BL 4.25–6.38; CL 2.06–2.35; AL 2.05–3.40, AW 1.24–2.17; ERW anterior 1.47–1.52; ERW median 1.26–1.33; ERW posterior 1.35–1.48; ALE–PME 0.42–0.43; ALE–PLE 1.01–1.09.

Description:

Male body. Carapace dorsally black or dark brown. Carapace with seven white patches of setae on dorsum, four in cephalic and three in thoracic part. Thoracic region with two small and one large white patches of setae. Lateral side of carapace strongly slope but

not vertical; lateral surface dark brown anteriorly; posterior part of lateral surface with longitudinal yellow band covered with white setae, extending from coxa I to coxa IV. Clypeus dark brown, with cluster of white setae. Chelicera dark brown, with two small prolateral and one large, triangle-shaped retrolateral teeth. Fang short, brown. Abdomen elongated, with large black band running longitudinally over dorsum located between the two yellow streaks; lateral margin of the yellow streak on lateral surface black. Legs I, II black or dark brown, except for yellowish cream tarsi, metatarsi and anterior part of tibia; legs III, IV brown; leg I stronger than others.

Male palp. Embolus long, thin, extending to direction of 1 o'clock. Anterior part of bulbus without retrolateral outgrowth. Posterior part of bulbus roundly developed, with unclear lope. Tibia long, about 1/2 the length of cymbium. Retrolateral tibial apophysis short, simple extending anteriorly.

Female body. Carapace dorsally brown or brown yellow. Thoracic part of carapace with two dark gray or black patches of setae. Lateral side almost vertical; lateral surface yellow, covered with white setae. Clypeus yellow, covered with white setae. Chelicera and fang yellow. Abdomen with two longitudinal gray or reddish brown streaks divided by yellowish field on dorsum; lateral surface covered with mixture of gray or reddish brown and white setae. Legs yellowish cream.

Female genitalia. Copulatory opening toward anteromedially, located far from spermatheca at anterior venter of genitalia. Copulatory duct longer than spermatheca diameter, connected to anterior venter of spermatheca; copulatory duct diameter wider than 1/3 of spermatheca diameter. Spermatheca oval. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Bac Can, Daklak, Hai Phong, Hanoi, Ha Tinh, Hoa Binh, Kien Giang, Lao Cai, Nghe An, Phu Tho, Quang Nam, Tay Ninh, Thanh Hoa, Tuyen Quang, Vinh Phuc, Yen Bai (Zabka, 1985, the present study); China; Hawaii; Korea; Japan; Malaysia; Sumatra; Taiwan.

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *Phintella versicolor* was Re-confirmed by the present integrated taxonomy. This species is morphologically similar *P. sancha*

Cao & Lee, 2016 and *P. squamata* (Zabka, 1985) in male abdomen with large black band running longitudinally over dorsum, but distinguishable from the latter by the pattern of carapace on dorsum with seven patches of white setae.

***Phintella vittata* (Koch, 1846)**

Fig. 4.12–4.14

Plexippus vittatus C. L. Koch, 1846: 125, f. 1185.

Hyllus alternans C. L. Koch, 1846: 1694, f. 1222.

Thiania vittata Simon, 1864: 326.

Thiania suavis Simon, 1885e: 439.

Maevia alternans Thorell, 1891: 83. — Workman & Workman, 1894: 11, pl. 11.

Maevia vittata Thorell, 1892c: 335.

Telamonia vittata Simon, 1901a: 540, 541, 548, f. 655.

Telamonia suavis Simon, 1901a: 548.

Salticus ranjitus Tikader, 1967: 117, f. 1a–c. — Tikader & Biswas, 1981: 89, f. 154–155.

Chrysilla vittata Prószyński, 1971e: 390.

Telamonia suavis Prószyński, 1978b: 336, f. 6. **Syn. nov**.

Phintella suavis Prószyński, 1984: 106. — Zabka, 1985: 427, f. 426–429, 451. — Peng *et al.*, 1993: 160, f. 560–564. — Song, Zhu & Chen, 1999: 539, f. 308M-N. — Cao, Li & Żabka, 2016: 91, f. 36A–D, 37A–E. **Syn. nov**.

Phintella vittata Zabka, 1985: 429, f. 435–441, 453. — Prószyński, 1990: 281. — Prószyński, 1992: 200, f. 148–152. — Peng *et al.*, 1993: 164, f. 577–585. — Song, Zhu & Chen, 1999: 539, f. 308Q. — Sen *et al.*, 2015: 37, f. 107–111, pl. 13. — Roy *et al.*, 2016: 18, f. 15A–E, 25D, 27K.

Phintella vittata Dhali, Saha & Raychaudhuri, 2017: 34, f. 73–77, pl. 18.

Type material examined: *Phintella vittata,* holotype, female; MfN, ZMB/Arach–1746; Indonesia, Bintang; leg. Koch. — *Phintella suavis,* holotype, male; MNHM, 4172; Malaysia, Malacca; leg. Morgan.

Non-type material examined: Vietnam: Sal-LP-0674, 1 female; Sal-LP-0675, 1 male; Vinh Phuc Province, Me Linh Biodiversity Station; 3.III.2015; leg. Luong; — Sal-LP-0768, 1 male; Sal-LP-0769, 1 female; Kien Giang Province, Phu Quoc National Park; 12.IX.2015; leg. Luong & Yamasaki. — Sal-LP-1549, 1 male; Sal-LP-1550, 1 male; Sal-LP-1551, 1 male; Sal-LP-1552, 1 male; Sal-LP-1553, 1 male; Sal-LP-1557, 1 female; Sal-LP-1558, 1 female; Thanh Hoa Province, Xuan Lien Natura Reserve; 9.IX.2016; leg. Luong. — IEBR-AR-0623, 3 males, 3 females; Quang Tri province, Dakrong Nature reserve; 8.X.2016; leg. Luong.

Diagnosis: Body of both sexes covered with metallic setae; dorsum of carapace and abdomen with transversal bands of black and metallic setae. Anterior part of bulbus of male palp with well-developed retrolateral outgrowth; retrolateral tibial apophysis curved, with roundly swollen basal surface. External posterior margin of female genitalia developed well protruding beyond the line of epigastric furrow.

Measurements: *Male* (n=10). BL 3.40–3.91; CL 1.7–1.94; AL 1.6–1.76, AW 1.07–1.26; ERW anterior 1.23–1.39; ERW median 0.97–1.24; ERW posterior 1.13–1.31; ALE–PME 0.37–0.40; ALE–PLE 0.81–0.93.

Female (n=6). BL 3.70–4.02; CL 1.63–1.63–; AL 1.59–2.35, AW 1.78; ERW anterior 1.14–1.17; ERW median 0.99–1.07; ERW posterior 1.12–1.15; ALE–PME 0.36–0.37; ALE–PLE 0.76–0.79.

Description:

Male body. Carapace dark brown, covered with metallic setae. Dorsum of carapace with transversal black band covered with black setae, located between the two bands of metallic setae on dorsum; posterior part of thorax black. Lateral side of carapace almost vertical; lateral surface black or dark brown. Clypeus black or dark brown, covered with metallic setae. Chelicera brown; prolateral margin of fang furrow bearing two small teeth basally, retrolateral margin bearing one large and one small tooth. Fang brown. The length of chelicera and fang show some variations. Abdomen brown; anterior part of abdomen covered with metallic setae; middle part with black bands running

transversally over dorsum, divided by metallic setae band; posterior part with large yellow band covered with yellow setae, and narrow band covered with metallic setae; posterior end black. Legs with brownish or gray tarsi and metatarsi, other segments dark gray or black.

Male palp. Embolus thin and short, extending to direction of 1 to 2 o'clock. Anterior part of bulbus with well-developed retrolateral outgrowth. Posterior lobe of bulbus large and long, tip of lobe extending to middle part of tibia in ventral view. Tibia short, about 1/3 the length of cymbium. Retrolateral tibial apophysis curved, short, extending to anterolaterally; basal surface roundly swollen.

Female body. Body pattern almost as in male. Clypeus black, covered with metallic setae. Chelicera and fang short, dark brown. Legs brownish yellow.

Female genitalia. Copulatory opening toward anterolateral of genitalia, located far from spermatheca at anterior venter of genitalia. Copulatory duct longer than spermatheca diameter, connected to posterior venter of spermatheca; copulatory duct diameter about 1/4 to 1/3 of spermatheca diameter. Spermatheca almost round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally. External posterior margin of genitalia developed well protruding beyond the line of epigastric furrow.

Distribution: Vietnam: Bac Can, Daklak, Ha Nam, Hanoi, Ha Tinh, Hoa Binh, Kien Giang, Nghe An, Ninh Binh, Phu Tho, Quang Nam, Quang Tri, Tay Ninh, Thai Nguyen, Thanh Hoa, Tuyen Quang, Vinh Phuc, Yen Bai (Zabka, 1985; the present study); India to Philippines.

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: The conspecificity of *Phintella vittata* and *P. suavis* and the male-female complementarity of *P. vittata* were confirmed by the present integrated taxonomy. This species is distinguishable from other *Phintella* species by metallic setae covered on dorsum and lateral surface of carapace and abdomen in both sexes.

Phintella sp. 1 n. nov.

Fig. 4.15

Type material examined: **Holotype**, female, Sal-LP-0582; Vietnam, Tuyen Quang Province, Na Hang Nature Reserve; 13.III.2015; leg. Luong & Yamasaki. — **Paratype**, 1 female, Sal-LP-0695; Vietnam, Tuyen Quang Province, Na Hang Nature Reserve; 13.III.2015; leg. Luong & Yamasaki.

Diagnosis: Abdomen of female covered with mixture of black or dark gray and white spots of setae on dorsum and lateral surface. Copulatory opening toward anteromedial of genitalia.

Measurements: *Female* (n=2). BL 5.79–5.93; CL 2.10–2.18; AL 3.27–3.47, AW 1.93–2.21; ERW anterior 1.37–1.44; ERW median 1.23–1.29; ERW posterior 1.31–1.40; ALE–PME 0.40–0.47; ALE–PLE 0.91–0.98.

Description:

Male. Unknown

Female body. Carapace brown, covered with white setae; thoracic part with two dark brown patches, covered with dark gray setae. Lateral sides almost vertical; lateral surface yellow covered with white setae. Clypeus brownish yellow, covered with white setae. Chelicera and fang brown. Abdomen covered with mixture of black or dark gray and white spots of setae on dorsum and lateral surface. Legs yellowish cream, surrounding joints dark gray.

Female genitalia. Copulatory opening toward anteromedially, located far from anterior part of spermatheca at anterior venter of genitalia. Copulatory duct longer than spermatheca diameter, connected to anterior venter of spermatheca; copulatory duct diameter larger than 1/3 of spermatheca diameter. Spermatheca oval. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Tuyen Quang.

Habitat: This species was found in secondary forests, on shrubs along forest edge.

Remarks: *Phintella* sp. 1 is morphologically similar to *P. squamata* (Zabka, 1985) in female abdomen with mixture of black or dark gray and white spots of setae on dorsum

and lateral surface, but distinguishable from the later by female genitalia with copulatory opening toward anteromedially, located far from anterior part of spermatheca.

Phintella sp. 2 n. nov.

Fig. 4.16

Type material examined: **Holotype**, female, Sal-LP-0168; Vietnam, Vinh Phuc Province, Tam Dao National Park; 07.VI.2014; leg. Luong & Yamasaki. — **Paratype**, 1 female, Sal-LP-0160; Vietnam, Vinh Phuc Province, Tam Dao National Park; 07.VI.2014; leg. Luong & Yamasaki.

Diagnosis: Copulatory opening toward anterior venter of epigyne. Copulatory duct curved, connected to anterolateral of spermatheca.

Measurements: *Female* (n=2). BL 4.33–4.41; CL 2.06–2.07; AL 2.17–2.22, AW 1.34–1.37; ERW anterior 1.42–1.45; ERW median 1.24–1.25; ERW posterior 1.36–1.39; ALE–PME 0.42–0.43; ALE–PLE 0.93–0.94.

Description:

Male. Unknown

Female body. Carapace dark brown; thoracic part with large yellow band on dorsum. Lateral side almost vertical, lateral surface brownish yellow anteriorly; posterior part of lateral surface with yellow band, covered with white setae. Clypeus dark brown. Chelicera brown. Abdomen gray anteriorly, with large yellow patch on dorsum; middle part of abdomen with yellow and black bands running transversally on dorsum; posterior part yellow, posterior end with black patch on dorsum. Legs yellowish cream.

Female genitalia: Copulatory opening toward anteriorly, located close to anterior margin of spermatheca at anterior venter of genitalia. Copulatory duct curved, not much longer than spermatheca diameter, connected to anterolateral side of spermatheca; copulatory duct diameter about 1/3 of spermatheca diameter. Spermatheca almost round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Vinh Phuc.

Habitat: This species was found in secondary forests, on shrubs along forest edge.

Remarks: *Phintella* sp. 2 is distinguishable from other *Phintella* species by female abdomen with yellow and black bands running transversally on dorsum; and female genitalia with curved copulatory duct; copulatory duct diameter about 1/3 of spermatheca diameter.

***Phintella* sp. 3 n. nov.**

Fig. 4.17

Type material examined: **Holotype**, male, Sal-LP-1067; Vietnam, Hanoi city, Ba Vi National Park; 29.II.2016; leg. Luong. — **Paratype**, 1 female, Sal-LP-1068, 1 male, Sal-LP-1069, 1 male, Sal-LP-1070; Vietnam, Hanoi city, Ba Vi National Park; 29.II.2016; leg. Luong; — 1 female, Sal-LP-1313, 1 male, Sal-LP-1455; Vietnam, Thanh Hoa province, Ben En National Park; 15.IX.2016; leg. Luong.

Diagnosis: Dorsum of abdomen in both sexes with four white patches anteriorly, four white patches in the middle, and two white patches posteriorly. Copulatory duct curved in opening part; copulatory opening toward lateral side of genitalia.

Measurements: *Male* (n=4). BL 3.18–3.29; CL 1.49–1.64; AL 1.51–1.59, AW 0.96–1.07; ERW anterior 1.20–1.22; ERW median 1.04–1.05; ERW posterior 1.16–1.19; ALE–PME 0.36–0.38; ALE–PLE 0.74–0.80.

Female (n=2). BL 2.51–3.21; CL 1.12–1.35; AL 1.29–1.82, AW 0.87–1.26; ERW anterior 0.80–1.11; ERW median 0.72–0.99; ERW posterior 0.77–1.09; ALE–PME 0.26–0.42; ALE–PLE 0.49–0.75.

Description:

Male body. Carapace brown, covered with black setae. Area between PME and PLE covered with white setae, forming white patch. Thoracic part of carapace with three patches of white setae and two large black patches on dorsum. Lateral side vertical; lateral surface dark brown, with yellow patch covered with white setae from coxa III to coxa IV. Clypeus brown; clypeus margin fringed with white setae. Chelicera brown,

with two small prolateral and one large retrolateral teeth. Abdomen covered with mixture of dark gray and brown yellow setae. Dorsum of abdomen with four white patches anteriorly, four white patches in the middle and two white patches posteriorly; those patches covered with white setae, and surrounding of those patches black or dark gray. Posterior end of abdomen black. Legs brown (except for black femur), covered with dark gray setae.

Male palp. Embolus short, extending to the direction of 1 o'clock. Anterior part of bulbus with well-developed flaky lamella outgrowth. Posterior lope of bulbus developed well, tip of lope extending to middle part of tibia. Tibia short, about 1/3 the length of cymbium. Retrolateral tibial apophysis short, extending anteriorly.

Female body. Carapace and abdomen almost as in male, but color pattern in female more lighter than that of in male. Legs brownish yellow.

Female genitalia. Copulatory opening toward lateral side of genitalia, located close to anterior part of spermatheca at anterior venter of genitalia. Copulatory duct curved in opening part; longer than spermatheca diameter; connected to posterior venter of spermatheca; copulatory duct diameter about 1/3 of spermatheca diameter. Spermatheca almost round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Hanoi, Thanh Hoa.

Habitat: This species was found in secondary forests, on shrubs along forest edges.

Remarks: The male-female complementarity of *P.* sp. 3 was newly confirmed by the present integrated taxonomy. This species is distinguishable from other *Phintella* species by abdomen pattern in both sexes with four white patches anteriorly, four white patches in the middle, and two white patches posteriorly.

***Phintella* sp. 4 n. nov.**

Fig. 4.18

Type material examined: **Holotype**, male, Sal-LP-1158; Vietnam, Daklak province, Chu Yang Sin National Park; 10.III.2016; leg. Luong. — **Paratype**, 1 male, Sal-LP-

1159, 1 male, Sal-LP-1160, 1 male, Sal-LP-1161, 1 female, Sal-LP-1162, 1 female, Sal-LP-1163, 1 female, Sal-LP-1164, 1 female, Sal-LP-1165; Vietnam, Daklak province, Chu Yang Sin National Park; 10.III.2016; leg. Luong.

Diagnosis: Abdomen of with large longitudinal yellowish cream streak running over dorsum; lateral surface of abdomen black, forming large longitudinal black streak. Female body almost white or yellowish cream; cephalic part of carapace covered with yellowish setae on dorsum.

Measurements: *Male* (n=3). BL 4.11–4.44; CL 1.97–2.21; AB 1.18–2.06, AW 0.92–1.18; ERW anterior 1.37–1.74; ERW median 1.21–1.44; ERW posterior 1.33–1.74; ALE–PME 0.39–0.52; ALE–PLE 0.87–1.16.

Female (n=4). BL 3.96–4.01; CL 1.81–1.91; AL 2.11–2.19, AW 1.12–1.14; ERW anterior 1.34–1.35; ERW median 1.13–1.17; ERW posterior 1.26–1.31; ALE–PME 0.39–0.41; ALE–PLE 0.91–0.92.

Description:

Male body. Carapace manly dark brown or dark gray, covered with black setae. Above anterior eyes on dorsum of carapace and area between ALE and PLE covered with yellowish yellow setae, forming yellow patches. Fovea and area behind fovea yellowish cream, covered with yellowish cream setae. Lateral side of carapace almost vertical, lateral surface dark brown. Clypeus brown, covered with white setae. Chelicera dark brown; prolateral margin of fang furrow bearing one small and one large teeth; retrolateral margin bearing one large tooth. Fang brown, short. Abdomen elongated pointed distally; abdomen with large longitudinal white band coverd with yellow setae running over durssum abdomen; lateral surface of abdomen dark gray covered with black setae, forming large longitudinal black streak. Legs mainly yellowish cream, except for black leg I. Leg I stronger than others.

Male palp. Embolus very short, extending to direction of over 2 o'clock. Anterior part of bulbus with developed retrolateral outgrowth. Posterior lobe well-developed, tip of lobe extending to anterior part of tibia. Tibia short, shorter than 1/3 the length of cymbium. Retrolateral tibial apophysis short, straight, extending anteriorly.

Female body. Carapace yellowish cream; cephalic part covered with yellow setae. Lateral side vertical, lateral surface whits. Embolus yellowish, covered with white setae. Chelicera brownish cream. Fang brown. Abdomen yellowish cream, with sparse gray setae; posterior part of abdomen more or less brownish gray on dorsum. Legs yellowish cream.

Female genitalia. Copulatory opening toward anteromedially, located close to anterior part of spermatheca at anterior venter of genitalia. Copulatory duct almost straight and same length with spermatheca diameter, connected to posterior venter of spermatheca; copulatory duct diameter about 1/3 of spermatheca diameter. Spermatheca almost round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Daklak.

Habitat: This species was found in secondary forests, on shrubs along forest trails.

Remarks: The male-female complementarity of *P.* sp. 4 was newly confirmed by the present integrated taxonomy. This species is distinguishable from other *Phintella* species by large yellow band on dorsum of male abdomen, and by female body pattern.

***Phintella* sp. 5 n. nov.**

Fig. 4.19

Type material examined: **Holotype**, male, Sal-LP-1673; Vietnam, Ha Tinh province, Vu Quang National Park; 19.III.2015; leg. Luong & Yamasaki. — **Paratype**, 1 male, Sal-LP-0720, 1 male, Sal-LP-0732; Vietnam, Ha Tinh province, Vu Quang National Park; 19.III.2015; leg. Luong & Yamasaki; — 1 male, Sal-LP-1674, 1 female, Sal-LP-1675, 1 female, Sal-LP-1679, 1 male, Sal-LP-1714, 1 male, Sal-LP-1715, 5 male, 5 female, IEBR-AR-0649; Vietnam, Gia Lai province, Kbang town; 12.III.2017; leg. Luong.

Diagnosis: Carapace and anterior part of abdomen in both sexes black on dorsum; posterior part of abdomen yellow. Copulatory duct of female genitalia long and large; copulatory duct length about 2 times of spermatheca diameter; copulatory duct diameter larger than 1/2 times of spermatheca diameter.

Measurements: *Male* (n=10). BL 2.11–3.62; CL 1.24–1.73; AL 0.81–1.74, AW 0.57–1.51; ERW anterior 0.96–1.37; ERW median 0.77–1.13; ERW posterior 0.81–1.27; ALE–PME 0.28–0.36; ALE–PLE 0.60–0.77.

Female (n=5). BL 2.50–4.22; CL 1.21–1.60; AL 1.20–2.39, AW 0.95–1.77; ERW anterior 0.88–1.32; ERW median 0.69–1.11; ERW posterior 0.81–1.25; ALE–PME 0.28–0.49; ALE–PLE 0.57–0.89.

Description:

Male body. Carapace black, covered with black setae. Area between PME and PLE, and fovea area covered with white setae, forming white patches. Laterall side vertical; lateral surface black or dark brown, posterior part with small part of white setae. Clypeus black. Chelicera gray brown, with two prolateral and one retrolateral teeth. Fang brown. Anterior part of abdomen black or dark brown; middle part with three patches of white setae on the dorsum and lateral surface; posterior part of abdomen yellow; posterior end black. Legs black, except for yellowish cream metatarsi and tarsi.

Male palp. Embolus short, extending to direction of over 12 o'clock. Anterior part of bulbus with round retrolateral outgrowth. Posterior lobe developed, tip of lobe extending to anterior part of tibia. Tibia length about 1/3 the length of cymbium. Retrolateral tibial apophysis extending anteriorly.

Female body. Carapace and abdomen almost similar as in male, except for anterior part of abdomen with two white patches of setae on dorsum. Legs yellowish cream.

Female genitalia. Copulatory opening toward anteromedially, located farfrom anterior part of spermatheca at anterior venter of genitalia. Copulatory duct length about 2 times of spermatheca diameter, connected to anterior venter of spermatheca; copulatory duct diameter larger than 1/2 of spermatheca diameter. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally

Distribution: Vietnam: Ha Tinh, Gia Lai.

Habitat: This species was found in secondary forests, on shrubs along along forest edges.

Remarks: The male-female complementarity of *P.* sp. 5 was newly confirmed by the present integrated taxonomy. This species is distinguishable from other *Phintella*

species by dorsum of abdomen in both sexes with black anteriorly and yellow posteriorly; and by long and large copulatory duct of *Female genitalia.*

***Phintella* sp. 6 n. nov.**

Fig. 4.20

Type material examined: **Holotype**, male, Sal-LP-0467; Vietnam, Vinh Phuc province, Me Linh Biodiversity station; 03.III.2015; leg. Luong. — **Paratype**, 1 female, Sal-LP-0475; Vietnam, Vinh Phuc province, Me Linh Biodiversity station; 03.III.2015; leg. Luong; — 1 female, Sal-LP-0644, 1 female, Sal-LP-0669; Vietnam, Ha Tinh province, Vu Quang National Park; 20.III.2015; leg. Luong & Yamasaki; — 1 female, Sal-LP-1603; Vietnam, Thanh Hoa province, Ben En National Park; 12.III.2015; leg. Luong.

Diagnosis: Abdomen of male with black band running longitudinally over dorsum, located between two yellow streaks. Abdomen of female mainly black, dorsum with yellow patches.

Measurements: *Male* (n=1). BL 4.04; CL 1.91; AL 2.08, AW 1.20; ERW anterior 1.31; ERW median 1.21; ERW posterior 1.33; ALE–PME 0.45; ALE–PLE 0.93.

Female (n=4). BL 3.39–4.39; CL 1.43–2.14; AL 1.89–2.15, AW 1.19–1.38; ERW anterior 1.01–1.46; ERW median 0.89–1.33; ERW posterior 1.03–1.46; ALE–PME 0.37–0.50; ALE–PLE 0.74–1.02.

Description:

Male body. Carapace dark brown, area below fovea reddish brown. Lateral side vertical, lateral surface dark brown, posterior part with yellow band, covered with white setae. Clypeus black. Chelicera brown, with two prolateral and one retrolateral teeth. Fang brown. Abdomen with black band running longitudinally over dorsum, located between two yellow streaks. Legs brownish yellow, except for dark brown femur and patella of legs I, II.

Male palp. Embolus thin and rather long, extending to direction of over 12 o'clock. Anterior part of bulbus without retrolateral outgrowth. Posterior part of bulbus round,

without lobe. Tibia length over 1/3 the length of cymbium. Retrolateral tibial apophysis extending anteriorly.

Female body. Carapace mainly dark brown covered with black setae. Above AME on dorsum of carapace and area between PME and PLE covered with white setae, formed white patches; thoracic part of carapace with large white patch of setae below fovea. Lateral side almost vertical; lateral surface with longitudinal yellow band covered with white setae. Clypeus brown yellow, covered with white setae. Chelicera and fang brown. Abdomen mainly black, anterior part of abdomen with longitudinal yellow band of seate on dorsum and lateral surface; middle part with three yellow patches of setae; posterior part with one large and two small yellow patches. Legs brownish gray; segments with white setae patches on dorsum.

Female genitalia. Copulatory opening toward anterolateral of genitalia, located far from anterior part of spermatheca. Copulatory duct length almost same spermatheca diameter, connected to anterior venter of spermatheca; copulatory duct diameter smaller than 1/4 of spermatheca diameter. Spermatheca almost round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Vinh Phuc, Thanh Hoa, Ha Tinh.

Habitat: This species was found in secondary forests, on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *P.* sp. 6 was newly confirmed by the present integrated taxonomy. This species is similar to *P. squamata*, *P. sancha* and *P. versicolor* in male abdomen with black band running longitudinally over dorsum, but distinguishable from *P. sancha* and *P. versicolor* by male palp with thin and rather long embolus; distinguishable from *P. squamata* by elongate bulbus.

***Phintella* sp. 7 n. nov.**

Fig. 4.21

Type material examined: **Holotype**, male, Sal-LP-0591; Vietnam, Ha Tinh province, Vu Quang National Park; 19.III.2015; leg. Luong & Yamasaki. — **Paratype**, 1 male, Sal-LP-0590, 1 female, Sal-LP-0602, 1 male, Sal-LP-0620, 1 male, Sal-LP-0621, 1

male, Sal-LP-0630, 1 male, Sal-LP-0723; Vietnam, Ha Tinh province, Vu Quang National Park; 19.III.2015; leg. Luong & Yamasaki; — 1 female, Sal-LP-0512, 1 male, Sal-LP-0576; Vietnam, Tuyen Quang province, Na Hang Natural Reserve; 10.III.2015; leg. Luong & Yamasaki; — 1 male, Sal-LP-1279; Vietnam, Thanh Hoa province, Xuan Lien Natural Reserve; 18.IV.2016; leg. Luong; — 1 female, Sal-LP-1422, 1 female, Sal-LP-1423, 1 male, Sal-LP-1424, 1 male, Sal-LP-1425; Vietnam, Thanh Hoa province, Ben En National Park; 18.IV.2016; leg. Luong; — 1 male, Sal-LP-1497, 1 female, Sal-LP-1499, 1 male, Sal-LP-1615, 1 male, Sal-LP-1616; Vietnam, Nghe An province, Pu Mat National Park; 25.IX.2016; leg. Luong; — 1 male, Sal-LP-1502, 1 female, Sal-LP-1503, 1 female, Sal-LP-1504, 1 male, Sal-LP-1624; Vietnam, Quang Tri province, Dakrong Natural Reserve; 06.X.2016; leg. Luong; — 1 male, Sal-LP-1672, 1 male, Sal-LP-1680; Vietnam, Gia Lai province, Kbang town; 12.III.2017; leg. Luong.

Diagnosis: Abdomen of male with large longitudinal yellow band running over dorsum; lateral surface of abdomen dark gray forming dark gray band. Female body yellowish cream; copulatory duct of female genitalia long, about two time of spermatheca diameter.

Measurements: *Male* (n=17). BL 3.06–4.54; CL 1.55–1.89; AL 1.51–2.58, AW 0.91–1.24; ERW anterior 1.13–1.41; ERW median 0.96–1.24; ERW posterior 1.06–1.41; ALE–PME 0.33–0.47; ALE–PLE 0.71–0.93.

Female (n=4). BL 2.56–3.85; CL 1.20–1.63; AL 1.31–2.13, AW 0.60–1.27; ERW anterior 0.83–1.20; ERW median 0.75–1.01; ERW posterior 0.81–1.13; ALE–PME 0.25–0.34; ALE–PLE 0.57–0.79.

Description:

Male body. Carapace mainly dark brown, covered with black setae. Above AME on dorsal of carapace, area between ALE and PLE and below fovea area yellowish brown, covered with white setae, forming white patches. Lateral side almost vertical; lateral surface dark brown, with yellow band covered with white setae running from over coxa II to coxa IV. Chelicera dark brown, long, with two prolateral and one large retrolateral teeth. Fang short, brown. Abdomen with large longitudinal yellow band running cover dorsum; lateral surface of abdomen black forming black band. Legs yellowish cream, except for black leg I; leg I stronger than others.

Male palp. Embolus short, extending to direction of over 1 o'clock. Anterior part of bulbus with flaky lamella outgrowth. Posterior lobe short, tip of lobe extending to anterior part of tibia. Tibia short, shorter than 1/3 the length of cymbium. Retrolateral tibial apophysis short, slightly curved, extending anteriorly.

Female body. Carapace yellowish cream; dorsum of cephalic region covered with yellow setae. Lateral side vertical, lateral surface yellowish cream. Clypeus yellowish cream, covered with white setae. Chelicera yellowish cream. Fang brown. Abdomen yellowish cream, covered with sparse of white setae. Legs yellowish cream.

Female genitalia. Copulatory opening toward lateral side of genitalia, located far from anterior margin of spermatheca at anterior venter of genitalia. Copulatory duct long, about 2 times of spermatheca diameter, connected to posterior venter of spermatheca. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolateraly.

Distribution: Vietnam: Tuyen Quang, Thanh Hoa, Nghe An, Ha Tinh, Quang Tri, Gia Lai.

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *P.* sp. 7 was newly confirmed by the present integrated taxonomy. This species is similar to *P.* sp. 4 in male abdomen with large longitudinal yellow band running cover dorsum; lateral surface of abdomen black forming black band, but distinguishable from the latter the length of copulatory duct of female genitalia (about 2 times of spermatheca diameter).

***Phintella* sp. 8 n. nov.**

Figs. 4.22

Type material examined: **Holotype**, male, Sal-LP-1383; Vietnam, Thanh Hoa province, Ben En National Park — **Paratype**, 1 male, Sal-LP-1567; Vietnam, Thanh Hoa province, Ben En National Park; 10.IX.2016; leg. Luong; — 1 female, Sal-LP-1492; Vietnam, Nghe An province, Pu Mat National Park; 25.IX.2016; leg. Luong; — 1 male, Sal-LP-1505; Vietnam, Quang Tri province, Dakrong Nature Reserve; 8.X.2016;

leg. Luong; — 1 male, Sal-LP-1681, 1 male, IEBR-AR-0654; Vietnam, Gia Lai province, Kbang town; 12.III.2017; leg. Luong.

Diagnosis: Male body mainly black, thorax of carapace with small patch of white setae on dorsum; abdomen with transversal band of white setae on dorsum. Copulatory duct of female genitalia curved in opening part, located in anterior venter of genitalia; copulatory opening toward posteriorly.

Measurements: *Male* (n=5). BL 2.50–2.64; CL 1.37–1.41; AL 1.09–1.13, AW 0.76–0.48; ERW anterior 1.07–1.08; ERW median 0.88–0.92; ERW posterior 1.03–1.09; ALE–PME 0.25–0.27; ALE–PLE 0.62–0.69.

Female (n=1). BL 2.79; CL 1.49; AL 1.22, AW 0.95; ERW anterior 1.05; ERW median 0.92; ERW posterior 1.05; ALE–PME 0.34; ALE–PLE 0.69.

Description:

Male body. Carapace black, thoracic part with white setae patch on dorsum. Lateral side vertical, lateral surface black. Clypeus dark brown. Chelicera brown, with two prolateral and one retrolateral teeth. Fang brown. Abdomen black; middle part of abdomen with transversal white setae band running over dorsum. Legs black, except for brownish yellow metatarsi and tarsi.

Male palp. Embolus straight, extending to direction of over 12 o'clock. Anterior part of bulbus without retrolateral outgrowth. Posterior lobe developed, tip of lobe extending to middle part of tibia. Tibia short, about 1/3 the length of cymbium. Retrolateral tibial apophysis slightly curved, extending anteriorly.

Female body. Carapace black, covered with black setae. Area between PME and PLE covered with white setae forming white patches. Thoracic part of carapace with large yellow band coverd with white setae on dorsum. Lateral side vertical, lateral surface gray. Clypeus gray. Chelicera yellowish gray. Fang brown. Abdomen yellow, mainly covered with black setae; dorsum and lateral surface with yellow patches covered with white setae; anterior part with four patches, middle part with four patches, and posterior part with two patches. Legs yellowish cream.

Female genitalia. Copulatory opening toward posteriorly, located far from anterior part of spermatheca at anterior venter of genitalia. Copulatory duct longer than spermatheca

diameter, connected to anterior venter of spermatheca; copulatory duct diameter about 1/3 of spermatheca diameter. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Thanh Hoa, Nghe An, Quang Tri, Gia Lai

Habitat: This species was found in secondary forests, on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *P.* sp. 8 was newly confirmed by the present integrated taxonomy. This species is distinguishable from other *Phintella* species by black abdomen of male with transversal band of white setae on dorsum.

***Phintella* sp. 9 n. nov.**

Fig. 4.23

Type material examined: **Holotype**, 1 male, Sal-LP-1203; Vietnam, Daklak province, Yokdon National Park; 14.III.2016; leg. Luong.

Diagnosis: Abdomen of male gray on dorsum, forming large longitudinal gray band running over dorsum. Embolus of male palp rather long, posterior lobe of palp small.

Measurements: *Male* (n=1). BL 4.71; CL 2.09; AL 2.50, AW 1.36; ERW anterior 1.57; ERW median 1.39; ERW posterior 1.51; ALE–PME 0.47; ALE–PLE 0.97.

Description:

Male body. Carapace black, mainly coverd with black setae, cephalic part with transversal band covered with white setae on dorsum; thoracic part with white patch of setae below forvea. Lateral side vertical, lateral surface dark gray with yellowish cream band covered with white setae, running from over coxa II to coxa IV. Clypeus yellowish cream, covered with white setae. Chelicera gray, with two prolateral and one retrolateral teeth. Abdomen gray on dorsum, forming large longitudinal gray band running over dorsum. Lateral surface of abdomen with longitudinal white streak, covered with white setae. Legs yellowish cream, except for leg I; leg I stronger than others.

Male palp. Embolus rather long, extending to direction of 1 o'clock. Anterior part of bulbus without retrolateral outgrowth. Posterior lobe small, tip of lobe extending to

anterior margin of tibia. Tibia short, about 1/3 the length of cymbium. Retrolateral tibial apophysis extending anteriorly.

Female. Unknown.

Distribution: Vietnam: Daklak

Habitat: This species was found in secondary forests, on shrubs along forest trail.

Remarks: *Phintella* sp. 9 is distinguishable from other *Phintella* species by male palp with rather long embolus, posterior lobe of bulbus small.

***Phintella* sp. 10 n. nov.**

Fig. 4.24

Type material examined: **Holotype**, male, Sal-LP-0775; Vietnam, Kien Giang province, Phu Quoc National Park; 08.IX.2015; leg. Luong & Yamasaki. — **Paratype**, 1 female, Sal-LP-0782, 1 female, Sal-LP-0869, 1 female, Sal-LP-1014; Vietnam, Kien Giang province, Phu Quoc National Park; 08.IX.2015; leg. Luong & Yamasaki; — 1 female, Sal-LP-0946, 1 female, Sal-LP-0967, 1 female, Sal-LP-0968, 1 female, Sal-LP-0696; Vietnam, Tay Ninh province, Lo Go Xa Mat National Park; 25.IX.2015; leg. Luong; — 1 male, Sal-LP-1676, 1 female, Sal-LP-1677, 1 male, Sal-LP-1678; Vietnam, Gia Lai province, Kbang town; 12.III.2017; leg. Luong.

Diagnosis: Abdomen of both sexes with four patches of white setae on dorsum. Basal of fang furrow of male chelicera bearing one long and large tooth. Tibia of male palp bearing two retrolateral tibial apophyses.

Measurements: *Male* (n=3). BL 4.96–5.50; CL 2.51–2.61; AL 2.48–2.68, AW 1.45–1.46; ERW anterior 1.65–1.70; ERW median 1.42–1.48; ERW posterior 1.60–1.65; ALE–PME 0.50–0.51; ALE–PLE 1.05–1.07.

Female (n=8). BL 4.12–4.54; CL 1.86–2.10; AL 1.81–2.36, AW 1.29–1.66; ERW anterior 1.28–1.49; ERW median 1.15–1.25; ERW posterior 1.26–1.42; ALE–PME 0.40–0.46; ALE–PLE 0.92–0.94.

Description:

Male body. Carapace mainly brown; above anterior eyes on dorsum of carapace and fin-shaped area behind fovea yellow covered with white setae. Lateral side of carapace strongly slope; lateral surface dark brown, with yellow band covered with white setae running from coxa II to posterior of thorax. Clypeus dark brown, margin fringed with white setae. Chelicera brown; basal of fang furrow bearing one long and large tooth; prolateral margin of fang furrow without or with one or two teeth. Fang brown. Anterior part on dorsum and lateral surface of abdomen gray; middle and posterior part on dorsum of abdomen yellow. Dorsum of abdomen with four white patches covered with white setae; posterior end with black patch. Leg I black, except for brown yellow metatarsi covered with white setae, and dark brown tarsi. Legs II, III and IV with brown yellow femur; patella and tibia black with white patch of setae on dorsum; metatarsi and tarsi brownish yellow, covered with white setae.

Male palp. Embolus short, extending to direction of 1 o'clock; anterior part of bulbus with small retrolateral tooth located beside embolus. Anterior part of bulbus without retrolateral outgrowth. Posterior lobe long and large, tip of lobe extending to middle part of tibia. Tibia short, about 1/3 the length of cymbium. Tibia bearing two retrolateral tibial apophyses; venter one black, thick, short, tip extending anteriorly; lateral one brown, wide, extending anterolaterally.

Female body. Cephalic part of carapace brown, above anterior eyes on dorsum of carapace covered with white setae. Thoracic part of carapace yellow, with two black patches covered with black setae; surrounding the black patches and PLE area covered with white setae. Lateral side vertical; lateral surface yellowish cream. Clypeus yellow, covered with white setae. Chelicera yellow. Fang brown. Abdomen brownish yellow, with four white patches of setae on dorsum; posterior margin of those patches black, covered with black setae; posterior end of abdomen with black patch. Legs grayish yellow.

Female genitalia. Copulatory opening toward anterolateral of genitalia, located close to anterior part of spermatheca at anterior venter of genitalia. Copulatory duct length almost same the length of spermatheca diameter, connected to posterior venter of spermatheca; copulatory duct diameter larger than 1/3 of spermatheca diameter.

Spermatheca soybean-shaped. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Gia Lai, Tay Ninh, Kien Giang.

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *P.* sp. 10 was newly confirmed by the present integrated taxonomy. This species is similar to *P. dives* (Simon, 1899) in abdomen of both sexes with four patches of white setae on dorsum, tibia of male palp bearing two retrolateral tibial apophyses; but distinguishable from the latter by the small retrolateral tooth in anterior part of bulbus of *Male palp.*

***Phintella* sp. 11 n. nov.**

Fig. 4.25

Type material examined: **Holotype**, male, Sal-LP-0826; Vietnam, Kien Giang province, Phu Quoc National Park; 13.IX.2015; leg. Luong & Yamasaki — **Paratype**, 1 male, Sal-LP-0827, 1 female, Sal-LP-0828, 1 female, Sal-LP-0999, 1 female, Sal-LP-1000, 1 female, Sal-LP-1001, 2 female, IEBR-AR-0414; Vietnam, Kien Giang province, Phu Quoc National Park; 13.IX.2015; leg. Luong & Yamasaki; — 1 male, Sal-LP-0958; Vietnam, Tay Ninh province, Lo Go Xa Mat National Park.

Diagnosis: Abdomen of both sexes with four patches of white setae on dorsum. Embolus of male palp short, bent posteriorly, extending to direction of 4 o'clock; tibia bearing two retrolateral tibial apophyses. Copulatory duct of female genitalia located in posterior venter of genitalia; copulatory opening toward the posteromedially.

Measurements: *Male* (n=3). BL 3.84–4.49; CL 1.95–2.36; AL 1.84–2.13, AW 1.00–1.01; ERW anterior 1.39–1.55; ERW median 1.15–1.21; ERW posterior 1.35–1.41; ALE–PME 0.47–0.51; ALE–PLE 0.97–0.99.

Female (n=6). BL 4.52–4.80; CL 1.89–2.20; AL 2.43–2.45, AW 1.64–1.43; ERW anterior 1.37–1.56; ERW median 1.09–1.26; ERW posterior 1.27–1.45; ALE–PME 0.45–0.46; ALE–PLE 0.92–1.07.

Description:

Male body. Carapace mainly brown; above anterior eyes on dorsum of carapace and fin-shaped area behind fovea yellow covered with white setae. Lateral side of carapace strongly slope; lateral surface dark brown, with yellow band covered with white setae running from coxa II to posterior of thorax. Clypeus dark brown, margin fringed with white setae. Chelicera brown; basal of fang furrow bearing one small tooth; prolateral margin of fang furrow without or with one tooth. Fang brown. Abdomen yellow on dorsum, with four white patches covered with white setae; posterior end with black patch. Leg I black, except for brown yellow metatarsi, and dark brown tarsi. Legs II, III and IV with brown yellow femur; patella and tibia black with white patch of setae on dorsum; metatarsi and tarsi brownish yellow.

Male palp. Embolus short, bent posteriorly, extending to direction of 4 o'clock. Anterior part of bulbus without retrolateral outgrowth. Posterior lobe long and large, tip of lobe extending to middle part of tibia. Tibia short, about 1/3 the length of cymbium. Tibia bearing two retrolateral tibial apophyses; venter black, short and narrow, extending anteriorly; lateral one brown, wider and longer than venter one, extending anteriorly.

Female body. Cephalic part of carapace brown, above anterior eyes on dorsum of carapace covered with white setae. Thoracic part of carapace yellow, with two black patches covered with black setae; anterior margin of the black patches and PLE area covered with white setae. Lateral side vertical; lateral surface yellowish cream. Clypeus yellow, covered with white setae. Chelicera yellow. Fang brown. Abdomen yellow, with four white patches of setae on dorsum; posterior margin of those patches black, covered with black setae; posterior end of abdomen with black patch. Legs grayish yellow.

Female genitalia. Copulatory opening toward posteromedially, located far from posterior part of spermatheca at posterior part of genitalia. Copulatory duct length almost same the length of spermatheca diameter, connected to posterior venter of spermatheca; copulatory duct diameter about 1/3 of spermatheca diameter. Spermatheca soybean-shaped. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Kien Giang, Tay Ninh.

Habitat: This species was found in secondary forests, on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *P.* sp. 11 was newly confirmed by the present integrated taxonomy. This species is similar to *P. dives* (Simon, 1899) and *P.* sp. 10 in abdomen of both sexes with four patches of white setae on dorsum, tibia of male palp bearing two retrolateral tibial apophyses; but distinguishable from the latter by embolus of male palp extending to direction of 4 o'clock; copulatory duct of female genitalia located in posterior venter of genitalia; copulatory opening toward the posteromedially.

Phintella sp. 12 n. nov.

Fig. 4.26

Type material examined: **Holotype**, male, Sal-LP-0632; Vietnam, Ha Tinh province, Vu Quang National Park; 20.III.2015; leg. Luong & Yamasaki — **Paratype**, 1 female, Sal-LP-0721, 1 female, Sal-LP-0722, 1 female, Sal-LP-0723; Vietnam, Ha Tinh province, Vu Quang National Park; 20.III.2015; leg. Luong & Yamasaki.

Diagnosis: Body and legs of male mainly black. Abdomen of male with white patch covered with white setae on dorsum. Abdomen of female with black and white band running transversally over dorsum. Copulatory duct curved, connected to posterior part of spermatheca; copulatory opening located in anterior venter of genitalia, toward laterally.

Measurements: *Male* (n=1). BL 4.28; CL 2.02; AL 2.16, AW 1.46; ERW anterior 1.34; ERW median 1.20; ERW posterior 1.29; ALE–PME 0.39; ALE–PLE 0.82.

Female (n=3). BL 3.24–3.93; CL 1.70–2.06; AL 1.50–1.76, width 1.05–1.20; ERW anterior 1.19–1.49; ERW median 0.99–1.31; ERW posterior 1.19–1.49; ALE–PME 0.36–0.46; ALE–PLE 0.77–1.01.

Description:

Male body. Carapace mainly black, covered with black setae. Area between PME and PLE covered with white setae forming white band. Thoracic part on dorsum with brown

yellow patch covered with white setae. Lateral side almost vertical; lateral surface dark brown; posterior part from coxa III to coxa IV covered with white setae. Clypeus dark brown, covered with sparse setae. Chelicera brown; prolateral margin of fang furrow bearing two small teeth basally, retrolateral margin bearing one tooth in anterior part of fang furrow. Fang brown. Abdomen dark gray, covered with black setae; middle part of abdomen with one white setae patch on dorsum and two small white patches on lateral surface. Legs almost black, except for brown tarsi.

Male palp. Embolus short, extending to direction of over 12 o'clock. Anterior part of bulbus with well-developed retrolateral outgrowth. Posterior lobe long and large, tip of lobe extending to middle part of tibia. Tibia rather long, about 1/2 the length of cymbium. Retrolateral tibial apophysis slightly curved, extending anteriorly.

Female body. Carapace dark brown, covered with black setae. Area between PME and PLE covered with white setae forming white patch. Thoracic part of carapace with brown yellow band covered with white setae. Lateral side vertical; lateral surface dark brown. Clyepeus dark brown. Chelicera and fang brown. Abdomen brown yellow; dorsum with one transversal band covered with white setae anteriorly; middle part of abdomen with one transversal band covered with white setae located between two transversal bands of black setae; posterior end of abdomen with two white setae patches divided by black patch on dorsum. Legs gray; patella, tibia and metatarsi with white patch of setae on dorsum.

Female genitalia. Copulatory opening toward lateral side of genitalia, located close to anterior margin of spermatheca at anterior venter of genitalia. Copulatory duct curved, longer than spermatheca diameter, connected to posterior venter of spermatheca. Spermatheca round. Fertilization duct connected to anterior dorsum of spermatheca, extending anterolaterally.

Distribution: Vietnam: Ha Tinh

Habitat: This species was found in secondary forests, often on shrubs along forest trails and along forest edges.

Remarks: The male-female complementarity of *P.* sp. 12 was newly confirmed by the present integrated taxonomy. This species is distinguishable from other *Phintella* by

abdomen of male with white patch covered with white setae on dorsum, and abdomen of female with black and white band running transversally over dorsum.

Phintella sp. 13 n. nov.

Fig. 4.27

Type material examined: **Holotype**, male, Sal-LP-1592; Vietnam, Thanh Hoa province, Ben En National Park; 18.IX.2016; leg. Luong.

Diagnosis: Male body covered with metallic setae. Abdomen dark gray, with one yellow and two black transversal bands running over dorsum, yellow band located between black bands. Basal surface of retrolateral tibial apophysis roundly swollen.

Measurements: *Male* (n=1). BL 3.49; CL 1.73; AL 1.67, AW 1.59; ERW anterior 1.21; ERW median 1.01; ERW posterior 1.23; ALE–PME 0.37; ALE–PLE 0.77.

Description:

Male body. Carapace covered with metallic setae. Cephalic part black on dorsum. Thoracic part dark brown, below fovea area yellowish brown. Lateral side almost vertical. Clypeus black, posterior margin fringed with metallic setae. Chelicera dark brown; prolateral margin of fang furrow bearing two small teeth basally; retrolateral margin with one large and one small tooth. Fang brown. Abdomen dark gray, covered with metallic setae; with one yellow and two black transversal bands running over dorsum, yellow band located between black bands. Legs black on dorsum, except for yellowish brown metatarsi and tarsi.

Male palp. Embolus thick, relatively straight, extending to direction of over 12 o'clock. Anterior part of bulbus with well-developed retrolateral outgrowth. Posterior lobe long and large, tip of lobe extending to middle part of tibia. Tibia short, about 1/3 the length of cymbium. Retrolateral tibial apophysis thick, extending anteriorly; basal surface roundly swollen.

Female. Unknown

Distribution: Vietnam: Thanh Hoa

Habitat: This species was found in secondary forests, on shrubs along forest edges.

Remarks: *Phintella* sp. 13 is similar to *P. vittata* (Koch, 1846) in male body covered with metallic setae, but distinguishable from the latter by retrolateral tibial apophysis thick, with roundly swollen basal surface.

References

Bodner M. R. & Maddison, W. P. 2012. The biogeography and age of salticid spider radiations (Araneae: Salticidae). Molecular Phylogenetics and Evolution 65: 213–240.

Bohdanowicz A. & Prószyński J. 1987. Systematic studies on East Palaearctic Salticidae (Araneae), IV. Salticidae of Japan. Annales Zoologici, Warszawa 41: 43–151.

Bösenberg W. & Strand E. 1906. Japanische Spinnen. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 30: 93–422.

Brignoli P. M. 1983. A catalogue of the Araneae described between 1940 and 1981. Manchester University Press 755 pp.

Cao X. W., Li S. Q. & Żabka M. 2016. The jumping spiders from Xishuangbanna, Yunnan, China (Araneae, Salticidae). ZooKeys 630: 43–104.

Chen X. E. & Gao J. C. 1990. The Sichuan farmland spiders in China. Sichuan Science and Technology Publishing House, Chengdu 226 pp.

Chen Z. F. & Zhang Z. H. 1991. Fauna of Zhejiang: Araneida. Zhejiang Science and Technology Publishing House 356 pp.

Chikuni Y. 1989. Pictorial Encyclopedia of Spiders in Japan. Kaisei–sha Publishing Co., Tokyo 310 pp.

Cho J. H. & Kim J. P. 2002. A revisional study of family Salticidae Blackwall, 1841 (Arachnida, Araneae) from Korea. Korean Arachnology 18: 85–169.

Dhali D. C., Saha S. & Raychaudhuri D. 2017. Litter and ground dwelling spiders (Araneae: Arachnida) of reserve forests of Dooars, West Bengal. World Scientific News 63: 1–242.

Feng Z. Q. 1990. Spiders of China in colour. Hunan Science and Technology Publishing House 256 pp.

Hedin M. C., & Maddison W. P. 2001. A combined molecular approach to phylogeny of the jumping spider subfamily Dendryphantinae (Araneae: Salticidae). Molecular Phylogenetics and Evolution 18(3): 386–403.

Hill D. E. and Richman. D. B. 2009. The evolution of jumping spiders (Araneae: Salticidae): a review. 75(1): 1–7.

Hu J. L. 1984. The Chinese spiders collected from the fields and the forests. Tianjin Press of Science and Techniques 482 pp.

Hu J. L. 2001. Spiders in Qinghai–Tibet Plateau of China. Henan Science and Technology Publishing House 658 pp.

Jackson R. R., & Harding D. P. 1982. Intraspecific interactions of *Holoplatys* sp. indet., a New Zealand jumping spider (Araneae: Salticidae). New Zealand journal of zoology 9(4): 487–510.

Jackson R. R., and Pollard S. D. 1996. Predatory behavior of jumping spiders. Annual Review of Entomology. 41: 287–308.

Jackson R. R., Pollard S. D., Nelson X. J., Edwards G. B., & Barrion A. T. 2001. Jumping spiders (Araneae: Salticidae) that feed on nectar. Journal of Zoology 255(1): 25–29.

Karsch F. 1879. Baustoffe zu einer Spinnenfauna von Japan. Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande und Westfalens 36: 57–105.

Kim J. P. & Cho, J. H. 2002. Spider: Natural Enemy & Resources. Korea Research Institute of Bioscience and Biotechnology (KRIBB) 424 pp.

Kim S. T. & Lee S. Y. 2014. Arthropoda: Arachnida: Araneae: Clubionidae, Corinnidae, Salticidae, Segestriidae. Spiders. Invertebrate Fauna of Korea 21(31): 1–186.

Koch C. L. 1846. Die Arachniden. Nürnberg, Dreizehnter Band, pp. 1–234, Vierzehnter Band 1–88.

Lee C. L. 1966). Spiders of Formosa (Taiwan). Taichung Junior Teachers College Publisher 84 pp.

Lee Y. B., Yoo J. S., Lee D. J. & Kim J. P. 2004. Ground dwelling spiders. Korean Arachnology 20: 97–115.

Logunov D. V. & Jäger P. 2015. Spiders from Vietnam (Arachnida: Aranei): new species and records. Russian Entomological Journal 24(4): 343–363.

Maddison W. 1987. Marchena and other jumping spiders with an apparent leg-carapace stridulatory mechanism (Araneae: Salticidae: Heliophaninae and Thiodinae). Bulletin of the British Arachnological Society 7: 101–106.

Maddison W. P. 1996. Pelegrina Franganillo and other jumping spiders formerly placed in the genus Metaphidippus (Araneae: Salticidae). Bulletin of the Museum of Comparative Zoology at Harvard College 154: 215–368.

Maddison W.P. & Hedin. M.C. 2003. Jumping spider phylogeny (Araneae: Salticidae). Invertebrate Systematics 17: 529–549.

Maddison W. P., Bodner M. R., & Needham K. M. 2008. Salticid spider phylogeny revisited, with the discovery of a large Australasian clade (Araneae: Salticidae). Zootaxa 1893: 49–64.

Maddison W. P., Li, D., Bodner M., Zhang J., Xu X., Liu Q., & Liu F. 2014. The deep phylogeny of jumping spiders (Araneae, Salticidae). ZooKeys 440: 57.

Maddison W. P. 2015. A phylogenetic classification of jumping spiders (Araneae: Salticidae). Journal of Arachnology 43(3): 231–292.

Matsumoto S. 1989. Colour variation in the prolateral side of the carapace and appendages of the jumping spider of the genus *Phintella* (Araneida: Salticidae). In: Nishikawa, Y. & H. Ono (eds.) Arachnological Papers Presented to Takeo Yaginuma on the Occasion of his Retirement. Osaka Arachnologists' Group, Osaka 123–131.

Namkung J. 2002. The spiders of Korea. Kyo-Hak Publishing Co., Seoul 648 pp.

Namkung J. 2003. The Spiders of Korea, 2nd. ed. Kyo-Hak Publishing Co., Seoul 648 pp.

Ono H., Ikeda H. & Kono R. 2009. Salticidae. In: Ono, H. (ed.) The Spiders of Japan with keys to the families and genera and illustrations of the species. Tokai University Press, Kanagawa 558–588.

Richman D. B., & Jackson, R. R. 1992. A review of the ethology of jumping spiders (Araneae, Salticidae). Bulletin of the British Arachnological Society 9(2): 33–37.

Roy T. K., Saha S. & Raychaudhuri D. 2016. A treatise on the jumping spiders (Araneae: Salticidae) of tea ecosystem of Dooars, West Bengal, India. World Scientific News 53(1): 1–66.

Paik K. Y. 1970. Spiders from Geojae–do Isl., Kyungnam, Korea. Theses Collection of the Graduate School of Education of Kyungpook National University 1: 83–93.

Paik K. Y. 1978. Araneae. Illustrated Fauna and Flora of Korea 21: 1–548.

Penney D. 2010. The evolution of jumping spiders (Araneae: Salticidae): the palaeontological evidence. Peckhamia 81(8): 1–3.

Peng X. J., Xie L. P., Xiao X. Q. & Yin C. M. 1993. Salticids in China (Arachniuda: Araneae). Hunan Normal University Press 270 pp.

Peng X. J. & Li S. Q. 2002. Four new and two newly recorded species of Taiwanese jumping spiders (Araneae: Salticidae) deposited in the United States. Zoological Studies 41: 337–345.

Prószyński J. 1971. Catalogue of Salticidae (Aranei) specimens kept in major collections of the world. Annales Zoologici, Warszawa 28: 367–519.

Prószyński J. 1973. Systematic studies on east Palearctic Salticidae, II. Redescriptions of Japanese Salticidae of the Zoological Museum in Berlin. Annales Zoologici, Warszawa 30: 97–128.

Prószyński J. 1978. Distributional patterns of the Palaearctic Salticidae (Araneae). Symposia of the Zoological Society of London 42: 335–343.

Prószyński J. 1983a. Position of genus Phintella (Araneae: Salticidae). Acta Arachnologica 31: 43–48.

Prószyński J. 1983b. Redescriptions of types of Oriental and Australian Salticidae (Aranea) in the Hungarian Natural History Museum, Budapest. Folia Entomologica Hungarica 44: 283–297.

Prószyński J. 1984. Atlas rysunków diagnostycznych mniej znanych Salticidae (Araneae). Wyższa Szkola Rolniczo–Pedagogiczna, Siedlcach 2: 1–177.

Prószyński J. 1987. Atlas rysunków diagnostycznych mniej znanych Salticidae 2. Zeszyty Naukowe Wyższej Szkoly Rolniczo-Pedagogicznej, Siedlcach 172 pp.

Prószyński J. 1990. Catalogue of Salticidae (Araneae): Synthesis of Quotations in the World Literature since 1940, with Basic Taxonomic Data since 1758. Wyższa Szkola Rolniczo-Pedagogiczna W Siedlcach 366 pp.

Prószyński J. 1992. Salticidae (Araneae) of India in the collection of the Hungarian National Natural History Museum in Budapest. Annales Zoologici, Warszawa 44: 165–277.

Prószyński J. 2016a. Delimitation and description of 19 new genera, a subgenus and a species of Salticidae (Araneae) of the world. Ecologica Montenegrina 7: 4–32.

Prószyński J. 2016b. Monograph of the Salticidae (Araneae) of the world 1995–2015. Version October 304th, 2016. Available online at: http://peckhamia.com/salticidae/.

Saitō S. 1959. The Spider Book Illustrated in Colours. Hokuryukan, Tokyo 194 pp.

Schenkel E. 1963. Ostasiatische Spinnen aus dem Muséum d'Histoire naturelle de Paris. Mémoires du Muséum National d'Histoire Naturelle de Paris (A, Zool.) 25: 1–481.

Seo B. K. 1995. Redescription and multivariate analysis of genus *Phintella* (Araneae, Salticidae) from Korea. Korean Journal of Systematic Zoology 11: 183–197.

Sen S., Dhali D. C., Saha S. & Raychaudhuri D. 2015. Spiders (Araneae: Arachnida) of Reserve Forests of Dooars: Gorumara National Park, Chapramari Wildlife Sanctuary and Mahananda Wildlife Sanctuary. World Scientific News 20: 1–339.

Shinkai E. 1969. Spiders of Tokyo. Arachnological Society of East Asia, Osaka, 65 pp.

Simon E. 1864. Histoire naturelle des araignées (aranéides). Paris 1–540.

Simon E. 1885. Matériaux pour servir à la faune arachnologiques de l'Asie méridionale. III. Arachnides recueillis en 1884 dans la presqu'île de Malacca, par M. J. Morgan. IV. Arachnides recueillis à Collegal, district de Coimbatoore, par M. A. Theobald G. R. Bulletin de la Société Zoologique de France 10: 436–462.

Simon E. 1899. Contribution à la faune de Sumatra. Arachnides recueillis par M. J. L. Weyers, à Sumatra. (Deuxiéme mémoire). Annales de la Société Entomologique de Belgique 43: 78–125.

Simon E. 1901. Histoire naturelle des araignées. Paris 2: 381–668.

Simon E. 1903. Etudes arachnologiques. 33e Mémoire. LIII. Arachnides recueillis à Phuc–Son (Annam) par M. H. Fruhstorfer (nov–dec. 1899). Annales de la Société Entomologique de France 71: 725–736.

Song D. X. (ed.) 1980. Farm Spiders. Science Press, Beijing 247 pp.

Song D. X. 1982. Some new records and synonyms of Chinese spiders. Zoological Research 3: 101–102.

Song D. X., Yu S. Y. & Yang H. F. 1982. A supplement note on some species of spiders from China. Acta Scientiarum Naturalium Universitatis Intramongolicae 13: 209–213.

Song D. X. 1987. Spiders from agricultural regions of China (Arachnida: Araneae). Agriculture Publishing House, Beijing 376 pp.

Song D. X., Zhu M. S. & Li S. Q. 1993. Arachnida: Araneae. In: Huang, C. M. (ed.) Animals of Longqi Mountai. China Forestry Publishing House, Beijing 852–890.

Song D. X., Chen J. & Zhu, M. S. 1997. Arachnida: Araneae. In: Yang, X. K. (ed.) Insects of the Three Gorge Reservoir area of Yangtze River. Chongqing Publishing House 2: 1704–1743.

Song D. X., Zhu M. S. & Chen J. 1999. The Spiders of China. Hebei University of Science and Techology Publishing House, Shijiazhuang 640 pp.

Strand E. 1907. Vorläufige Diagnosen süd– und ostasiatischer Clubioniden, Ageleniden, Pisauriden, Lycosiden, Oxyopiden und Salticiden. Zoologischer Anzeiger 31: 558–570.

Tikader B. K. 1967. Studies on some Salticidae spider from Sikkim, Himalaya, India. Proceedings of the Indian Academy of Science 66(B): 117–122.

Tikader B. K. & Biswas B. 1981. Spider fauna of Calcutta and vicinity: Part–I. Records of the Zoological Survey of India, Occasional Paper 30: 1–149.

Thorell T. 1891. Spindlar från Nikobarerna och andra delar af södra Asien. Bihang till Kongliga Svenska Vetenskaps–Akademiens Handlingar 24(2): 1–149.

Thorell T. 1892. Studi sui ragni Malesi e Papuani. IV, 2. Annali del Museo Civico di Storia Naturale di Genova 31: 1–490.

Walckenaer C. A. 1847. Dernier Supplément. In: Walckenaer, C. A. & P. Gervais (eds.) Histoire naturelles des Insects. Aptères. Paris 4: 365–564.

Wesolowska W. 1981a. Salticidae (Aranei) from North Korea, China and Mongolia. Annales Zoologici, Warszawa 36: 45–83.

Wesolowska W. 1981b. Redescriptions of the E. Schenkel's East Asiatic Salticidae (Aranei). Annales Zoologici, Warszawa 36: 127–160.

Workman T. & Workman M. E. 1894. Malaysian spiders. Belfast 9–24.

World Spider Catalog 2017. World Spider Catalog. Natural History Museum Bern. Available at http://wsc.nmbe.ch, version 17.5 (accessed 2017).

Xie L. P. 1993. New records of Salticidae from China (Arachnida: Araneae). Acta Scientiarum Naturalium Universitatis Normalis Hunanensis 16: 358–361.

Yaginuma T. 1955. Revision of scientific names of Japanese spiders. Atypus 8: 13–16.

Yaginuma T. 1960. Spiders of Japan in colour. Hoikusha, Osaka 186 pp.

Yaginuma T. 1971. Spiders of Japan in colour (enlarged and revised edition). Hoikusha, Osaka 197 pp.

Yaginuma T. 1977. A list of Japanese spiders (revised in 1977). Acta Arachnologica 27: 367–406.

Yaginuma T. 1986. Spiders of Japan in color (new ed.). Hoikusha Publishing Co., Osaka.

Yin C. M. & Wang J. F. 1979. A classification of the jumping spiders (Araneae, Salticidae) collected from the agricultural fields and other habitats. Journal of Hunan Teachers College (nat. Sci. Ed.) 1979(1): 27–63.

Yin C. M., Peng X. J., Yan H. M., Bao Y. H., Xu X., Tang G., Zhou Q. S. & Liu P. 2012. Fauna Hunan: Araneae in Hunan, China. Hunan Science and Technology Press, Changsha 1590 pp.

Zhao J. Z. 1993. Spiders in the Cotton Fields in China. Wuhan Publishing House, Wuhan, China 552 pp.

Zabka M. 1985. Systematic and zoogeographic study on the family Salticidae (Araneae) from Vietnam. Annales Zoologici Warszawa 11: 1–485.

Żabka M. 2012. Phlegra Simon, 1876, Phintella Strand 1906 and Yamangalea Maddison, 2009 (Arachnida: Araneae: Salticidae)—new species and new generic records for Australia. Zootaxa 3176: 61–68.

Zhu M. S. & Zhang B. S. 2011. Spider Fauna of Henan: Arachnida: Araneae. Science Press, Beijing 558 pp.

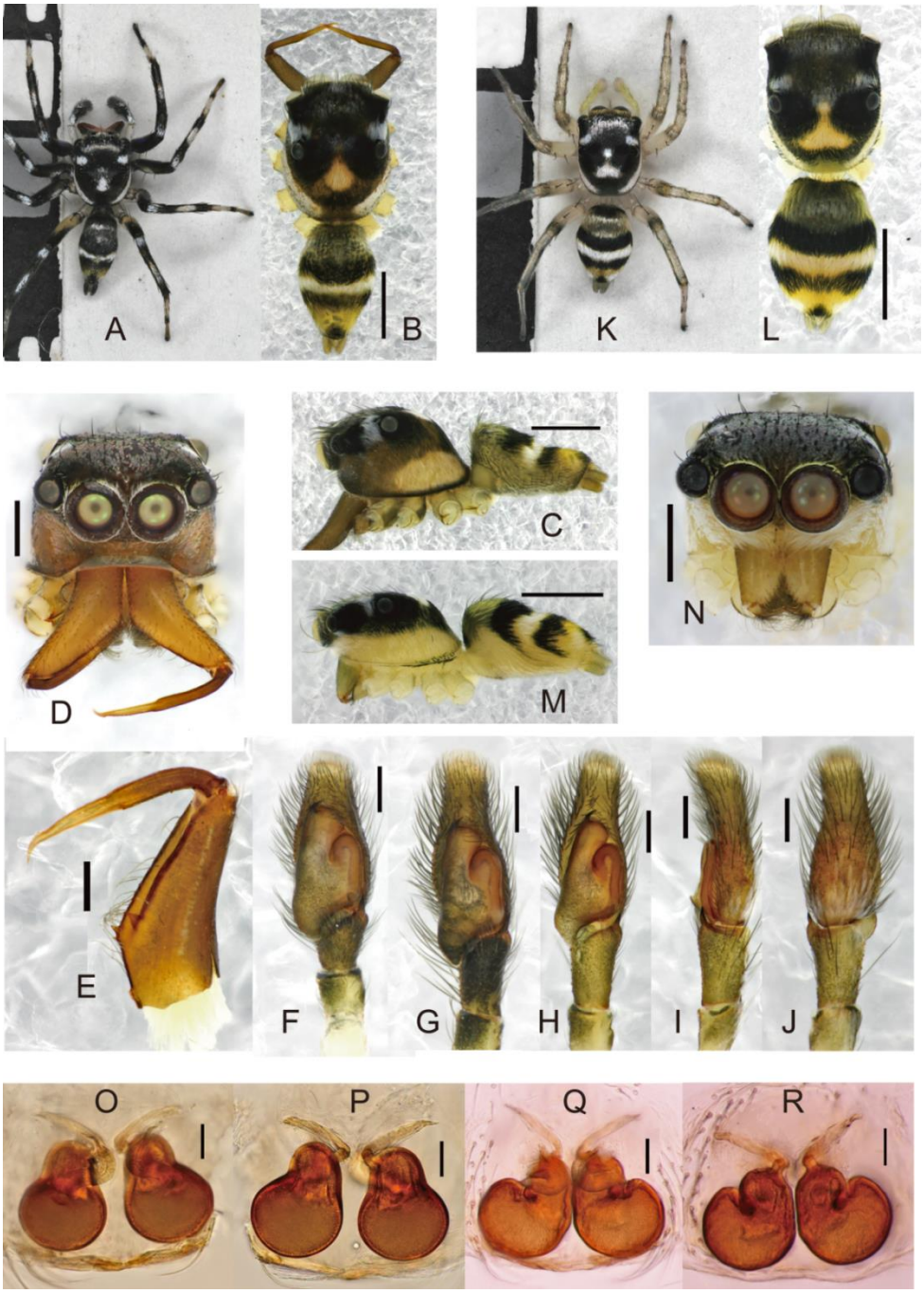

Figure 4.1. *P. aequipeiformis* from Vietnam. Male (A–J), Female (K–R). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F–H) palp, ventral view. (I) palp, retrolateral view. (J) palp, dorsal view. (K, L) body dorsal view. (M) body, lateral view. (N) prosoma, frontal view. (O, Q) genitalia ventral view. (P, R) genitalia dorsal view. Scale line 1 mm (A–C, K–M), 0.5 mm (D, N), 0.2 mm (E–J), 0.05 mm (O–R).

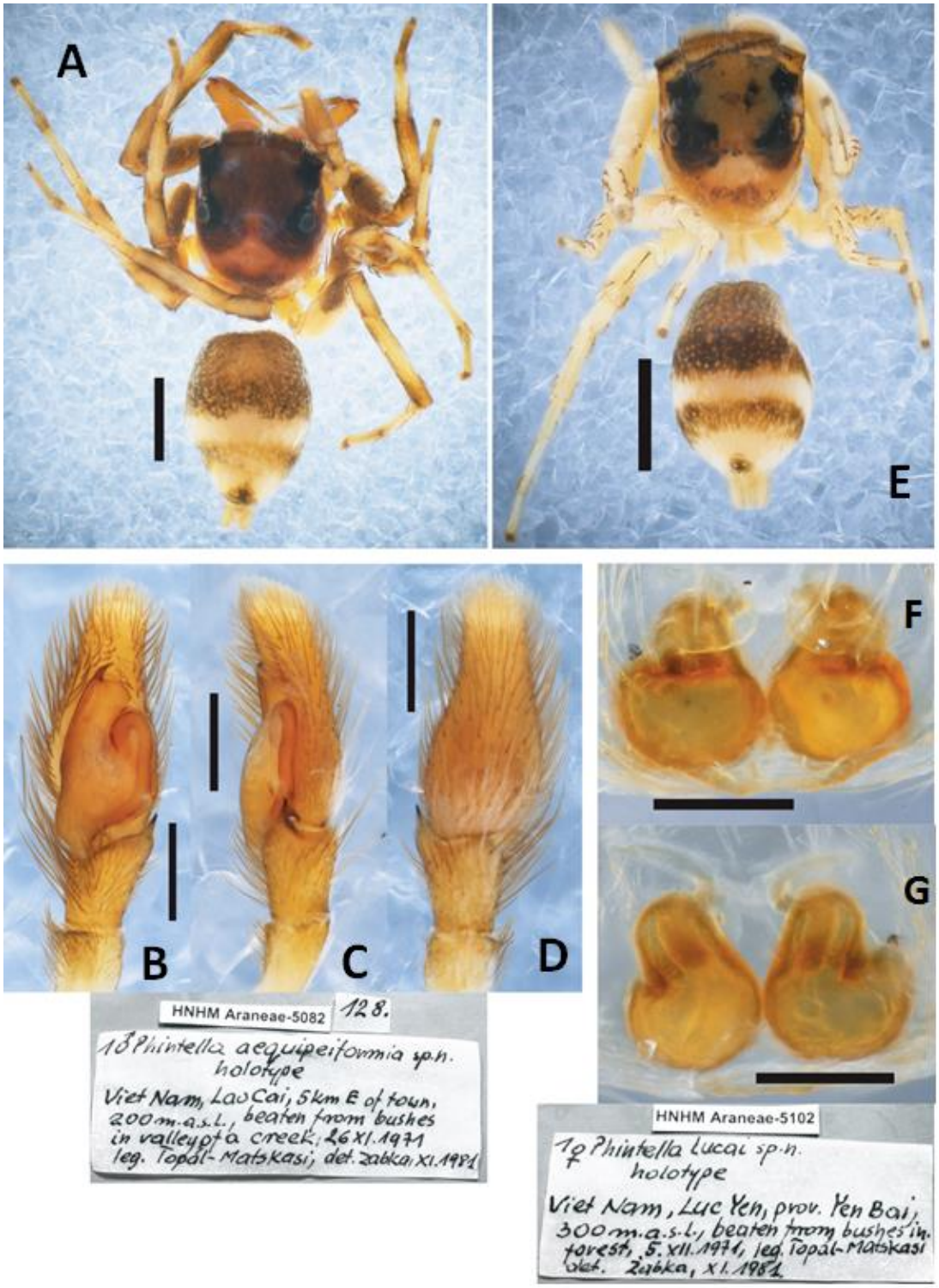

Figure 4.2. Type specimens of *P. aequipeiformis* (Male, A–D) and *P. lucai* (Female, E–G). (A) body, dorsal view. (B) palp, ventral view. (C) palp, retrolateral view. (D) palp, dorsal view. Female. (E) body, dorsal view. (F) genitalia, ventral view. (G) genitalia, dorsal view. Scale line 1 mm (A, E), 0.3 mm (B–D), 0.1 mm (F–G).

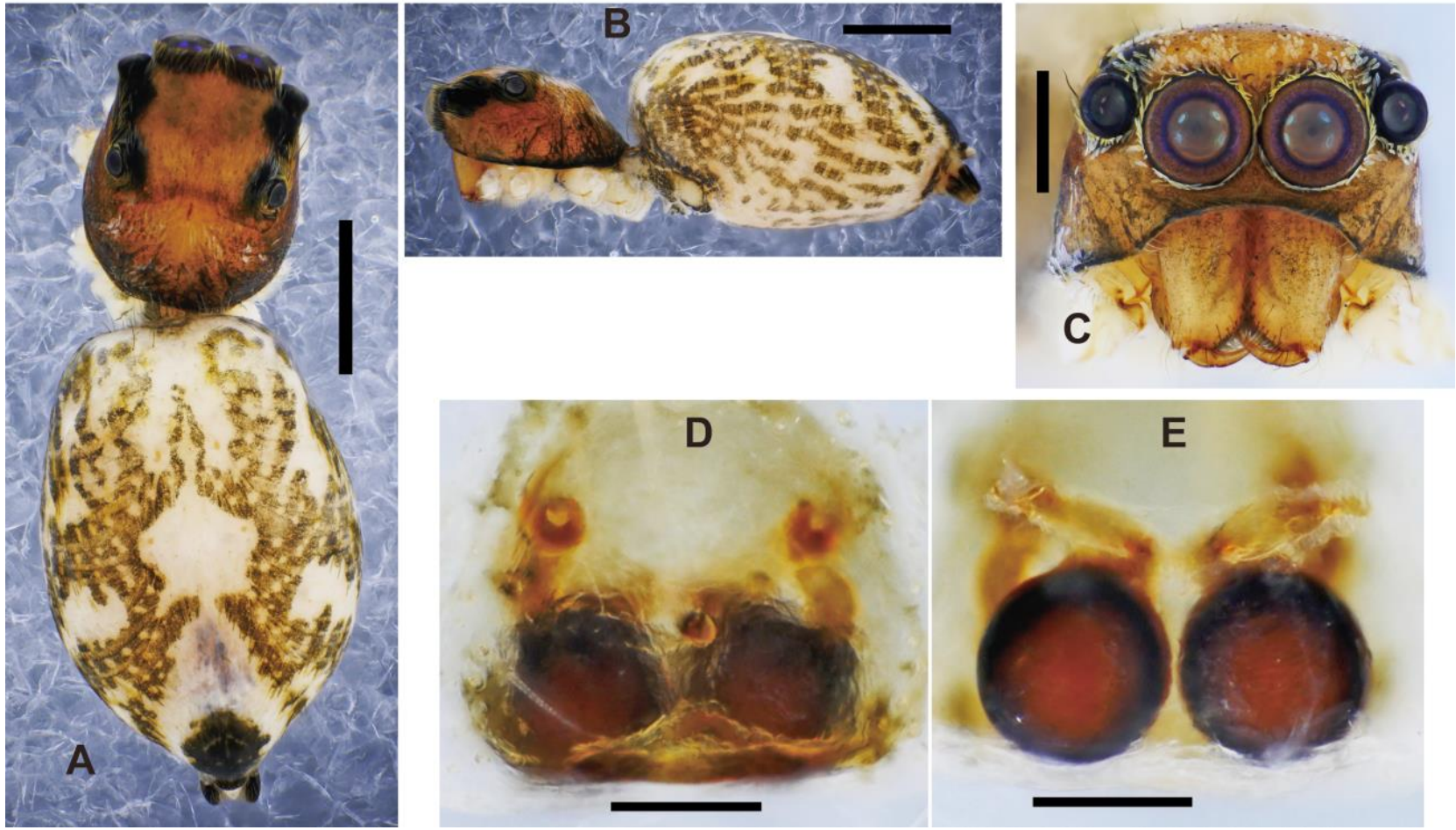

Figure 4.3. *P. cavaleriei*. Female. (A) body, dorsal view. (B) body, lateral view. (C) prosoma, frontal view. (D) genitalia, ventral view. (E) genitalia, dorsal view. Scale line 1 mm (A–B), 0.5 mm (C), 0.1 mm (D–E).

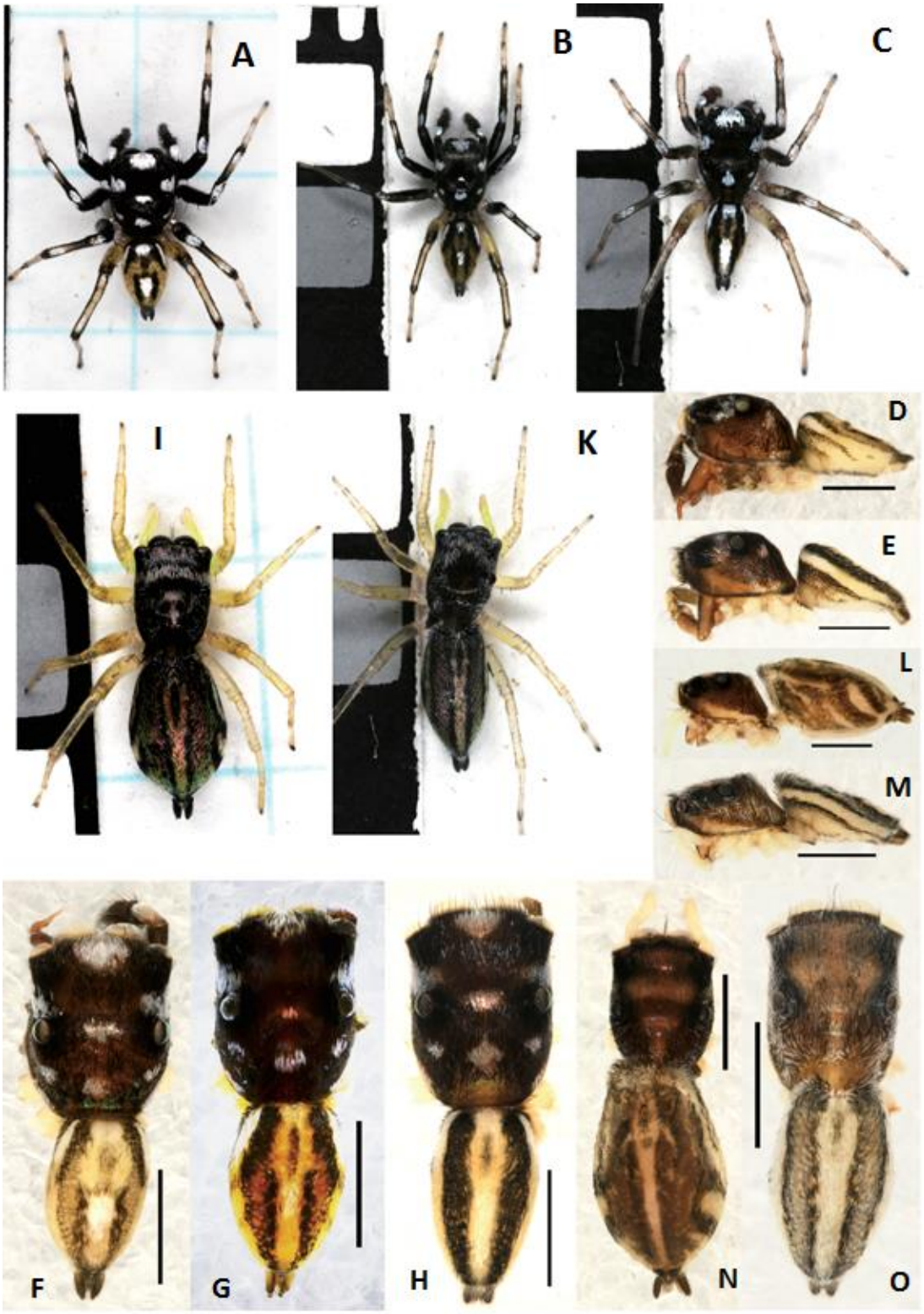

Figure 4.4. *P. debilis* from Vietnam. Male (A–H), Female (I–O). (A–C, F–H) body, dorsal view. (D, E) body, lateral view. (I–O) body, dorsal view. (L, M) body, lateral view. Scale line 1 mm (A–O).

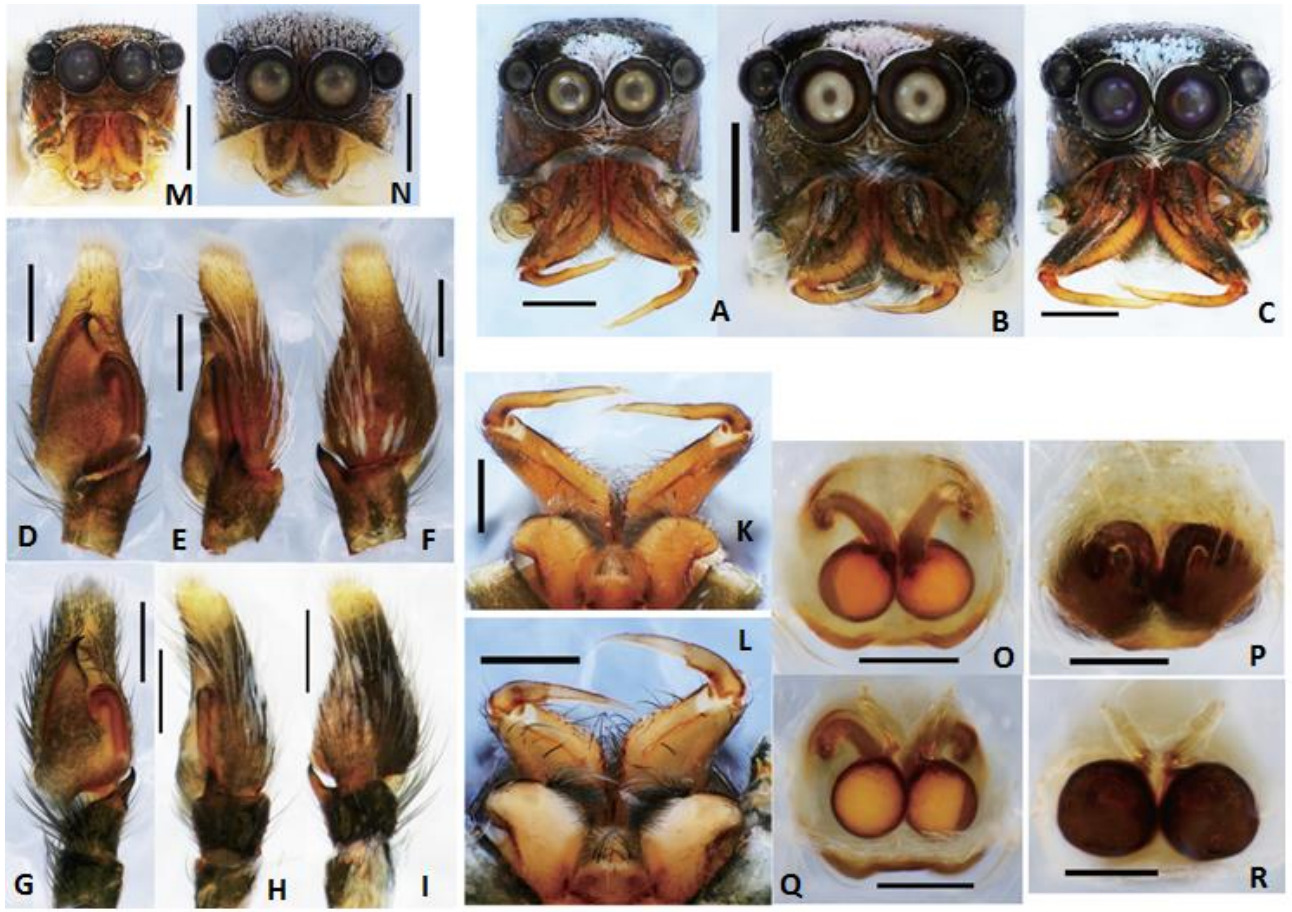

Figure 4.5. *P. debilis* from Vietnam. Male (A–L), Female (M-R). (A–C) prosoma, frontal view. (D, G) palp, ventral view. (E, H), palp, retrolateral view. (F, I) palp, dorsal view. (K, L) chelicera and fang, ventral view. (M, N) prosoma, frontal view. (O, P) genitalia, ventral view. (Q, R) genitalia, dorsal view. Scale line 0.5 mm (A–C, M–N), 0.3 mm (K, L), 0.2 mm (D–I), 0.1 mm (O–R).

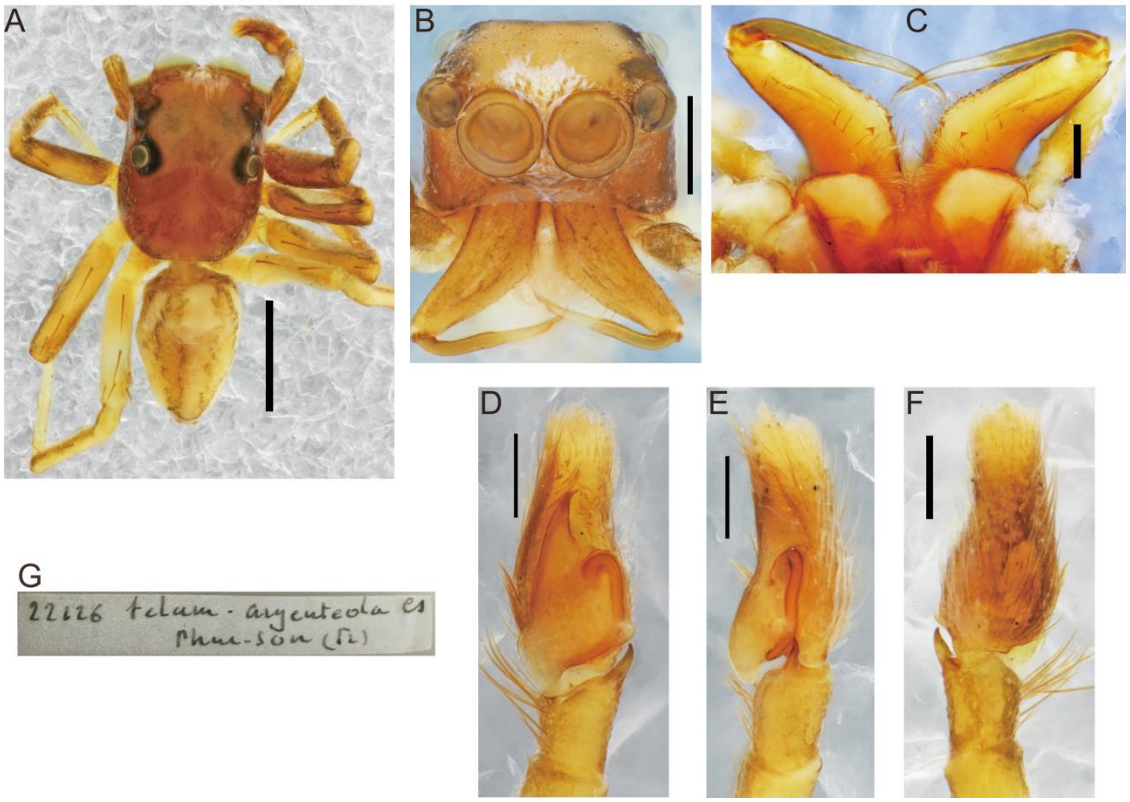

Figure 4.6. Type specimens of *P. argenteola* (Simon, 1903). Male. (A) body, dorsal view. (B) prosoma, frontal view. (C) chelicera and fang, ventral view. (D) palp, ventral view. (E) palp, retrolateral view. (F) palp, dorsal view. (G), museum label. Scale line 1 mm (A), 0.5 mm (B–C), 0.2 mm (D–F).

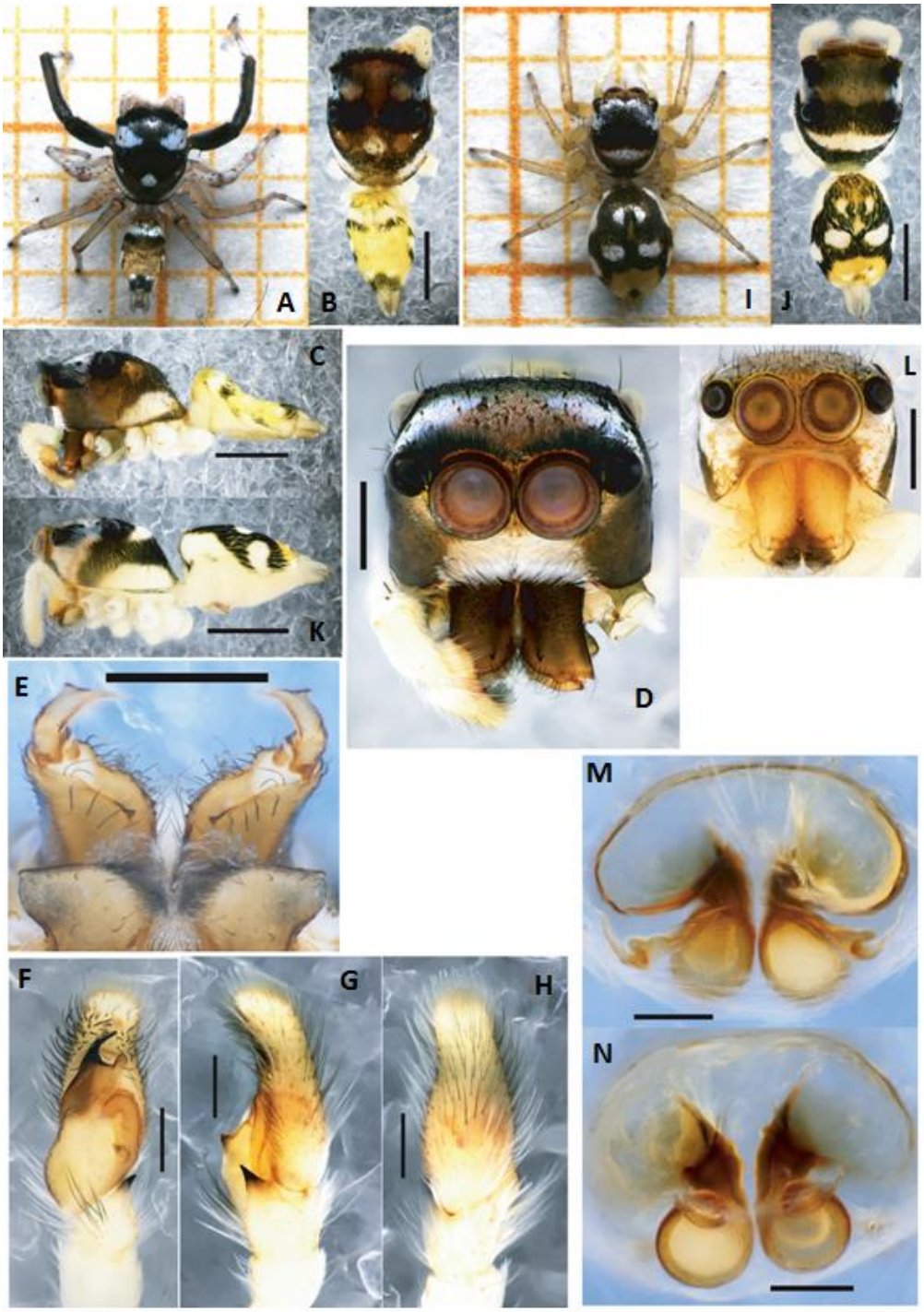

Figure 4.7. *P. lepidus* from Vietnam. Male (A–H), Female (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I, J) body, dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, E, L), 0.2 mm (F–H), 0.1 mm (M-N).

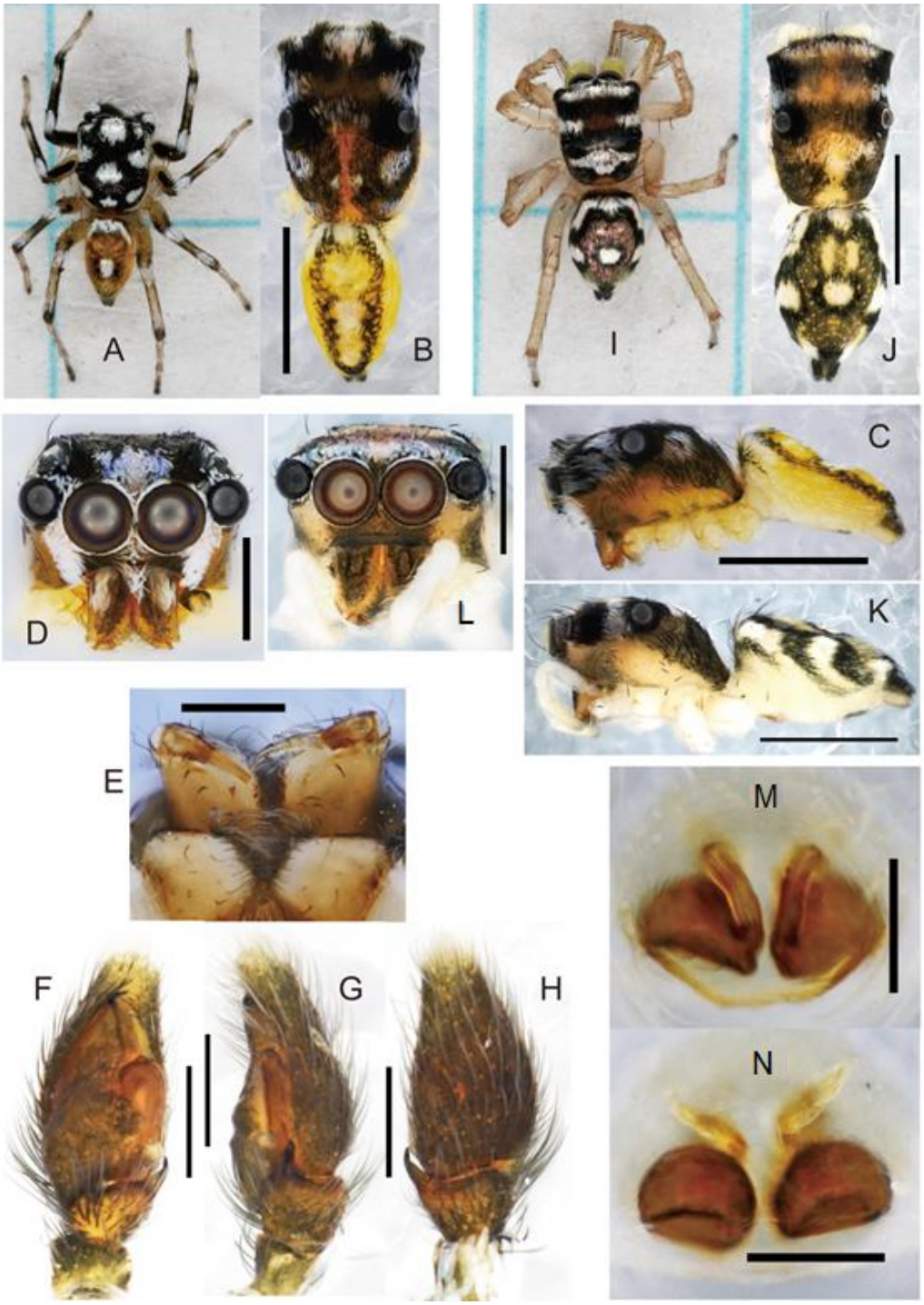

Figure 4.8. *P. monteithi* from Vietnam. Male (A–H), Female (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, L), 0.2 mm (E–H), 0.1 mm (M–N).

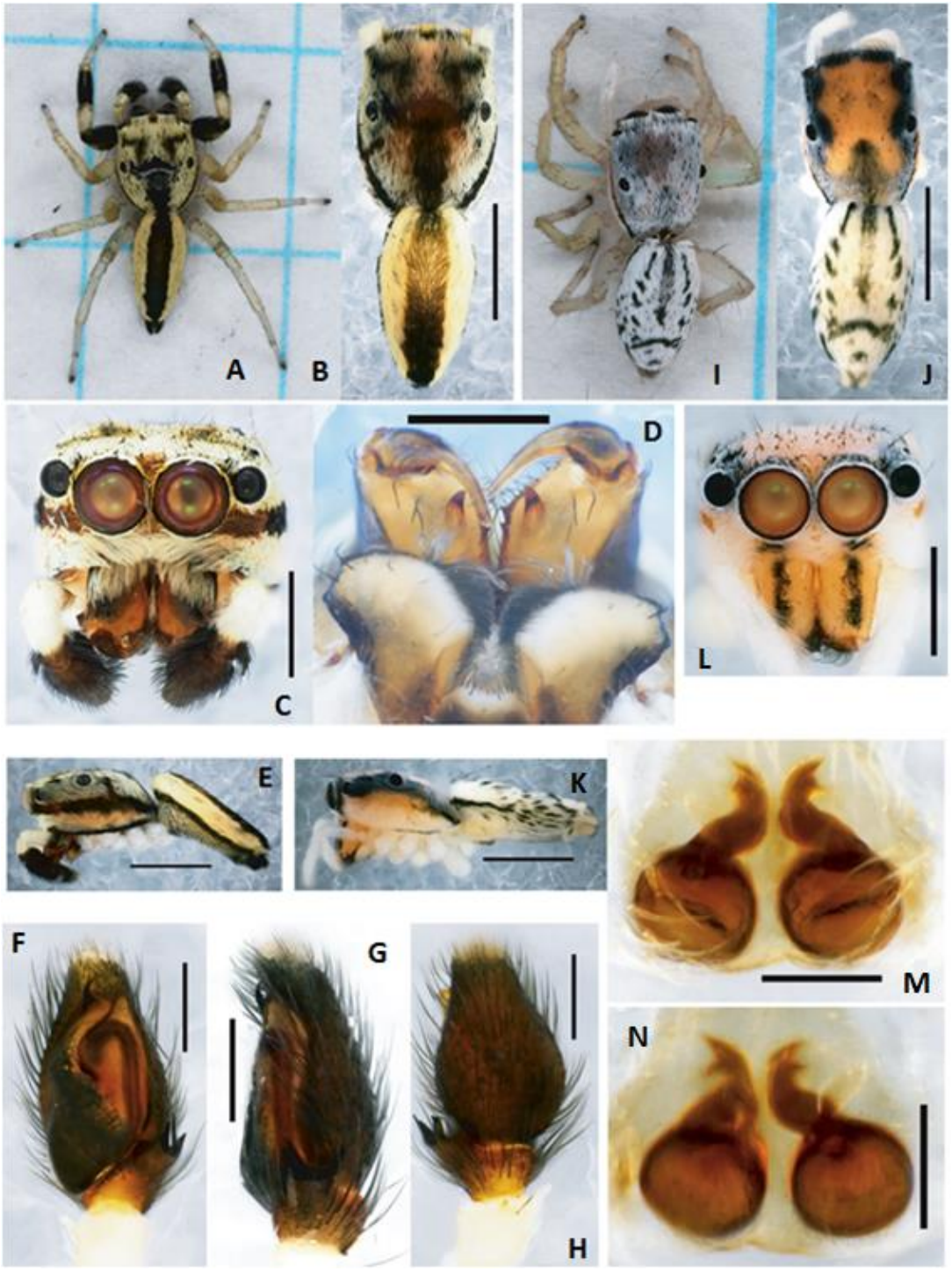

Figure 4.9. *P. sancha* from Vietnam. Male (A–H), Female (I–N). (A–B) body, dorsal view. (C) prosoma, frontal view. (D) chelicera and fang, ventral view. (E) body, lateral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–B, E, I–K), 0.5 mm (C, L), 0.3 mm (D), 0.2 mm (F–H), 0.1 mm (M–N).

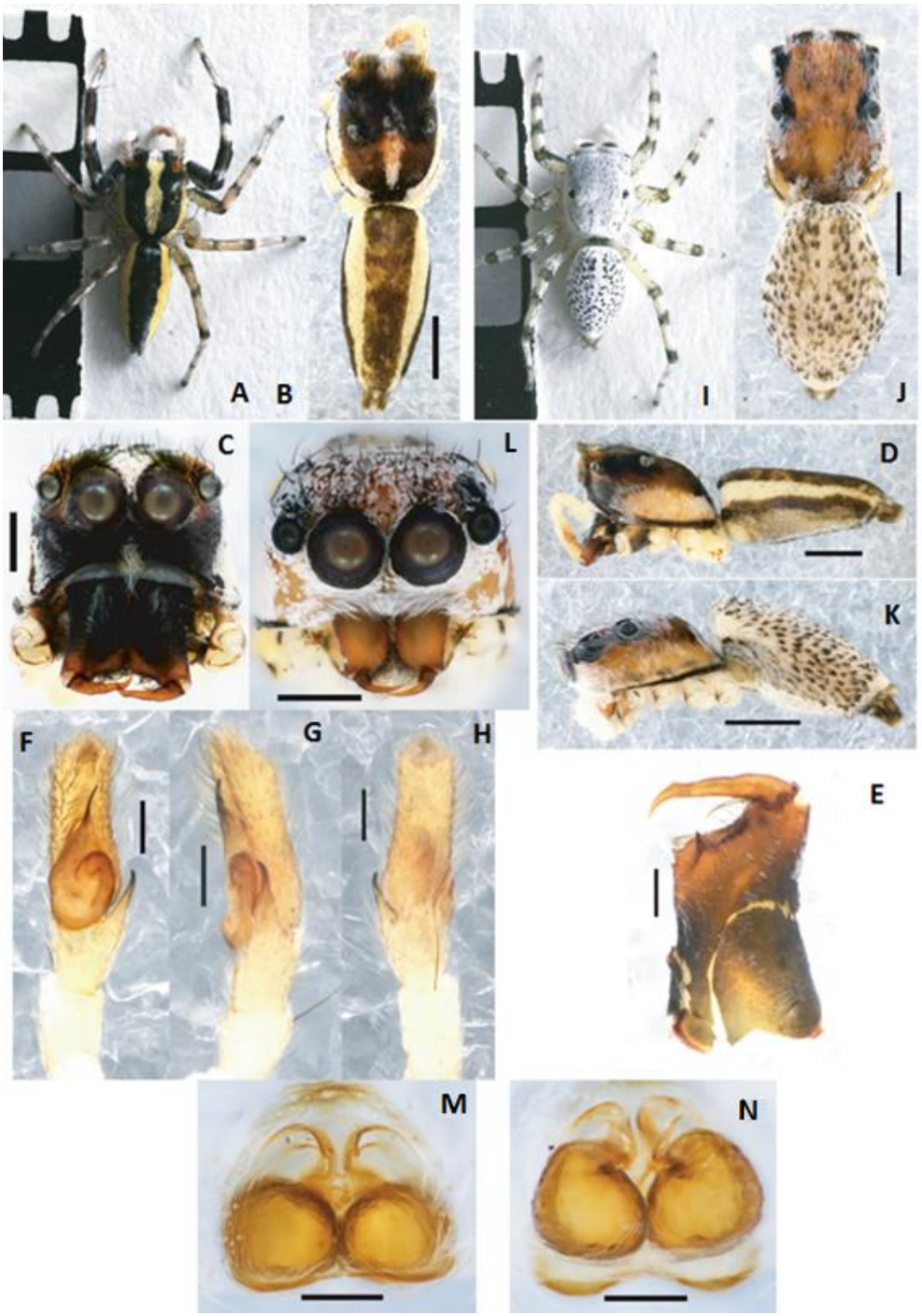

Figure 4.10. *P. squamata* from Vietnam. Male (A–H), Female (I–N). (A–B) body, dorsal view. (D) body, lateral view. (C) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I, J) body, dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–B, D, I–K), 0.5 mm (C, L), 0.2 mm (E–H), 0.1 mm (M–N)

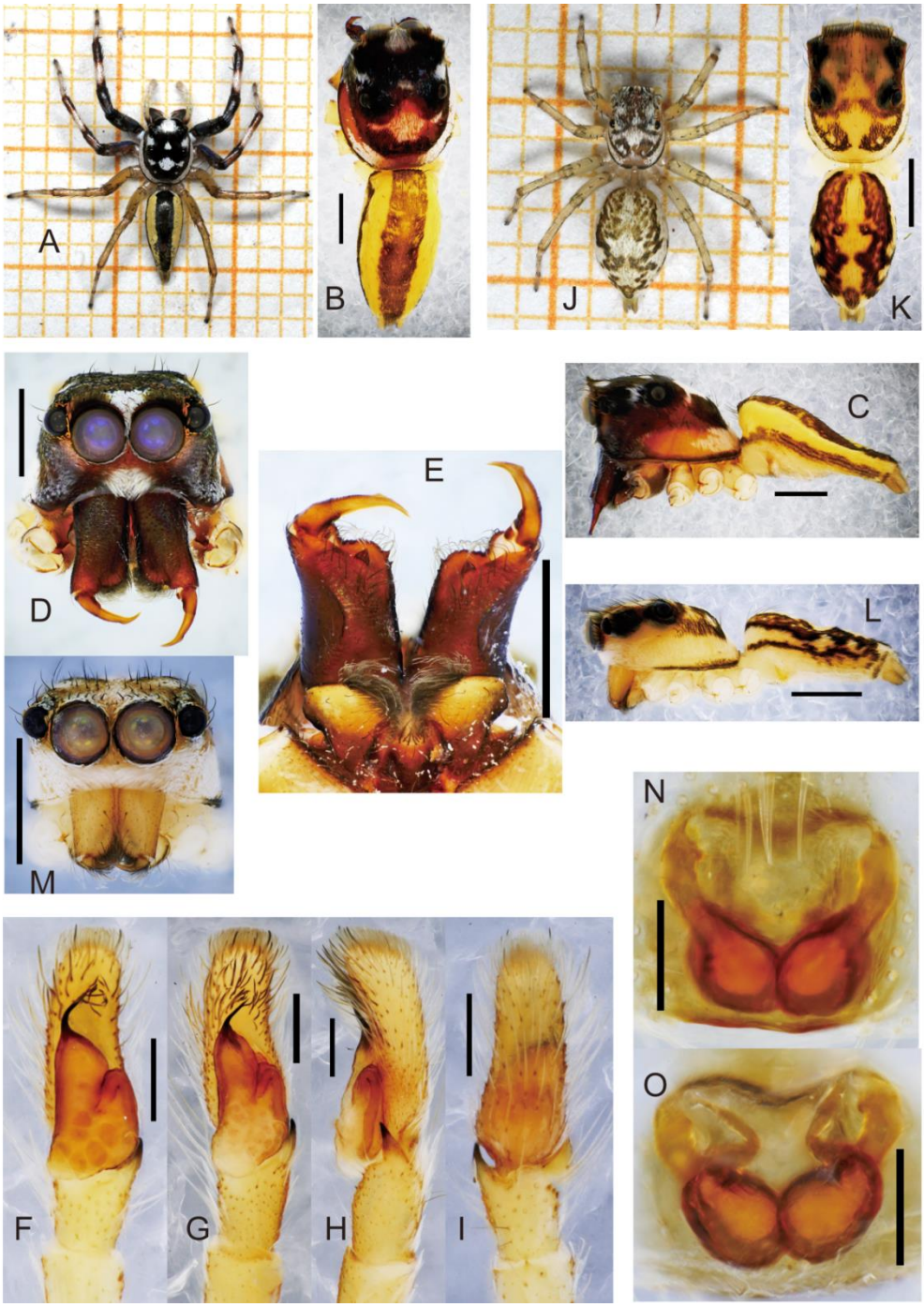

Figure 4.11. *P. versicolor* from Vietnam. Male (A–I), Female (J–O). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F, G) palp, ventral view. (H) palp, retrolateral view. (I) palp, dorsal view. (J, K) body, dorsal view. (L) body, lateral view. (M) prosoma, frontal view. (N) genitalia, ventral view. (O) genitalia, dorsal view. Scale line 1 mm (A–E, I–M), 0.2 mm (F–I), 0.1 mm (N–O).

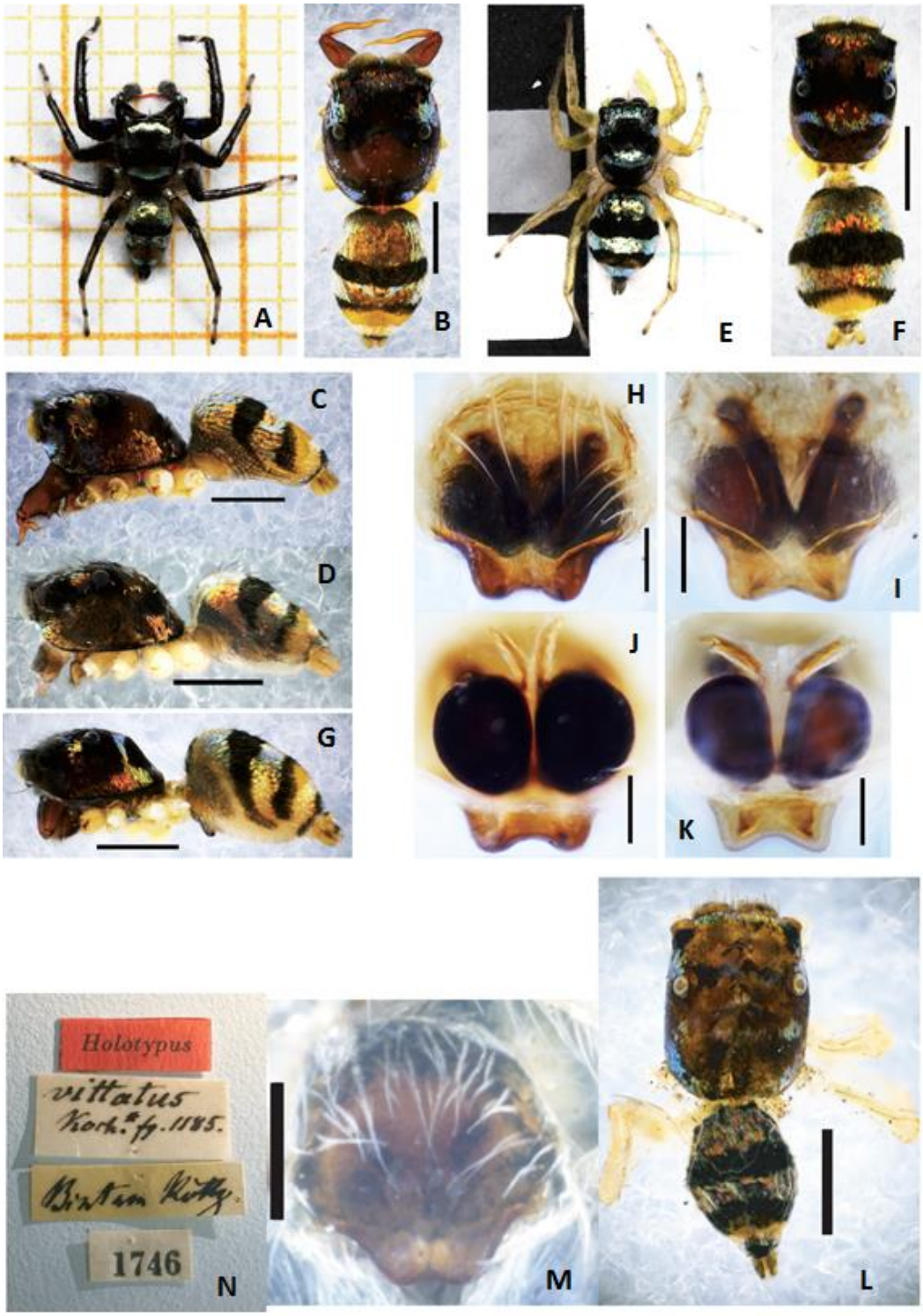

Figure 4.12. *P. vittata.* Vietnam: Male (A–D), Female (E–K). (A–B) body, dorsal view. (C,D) body, lateral view. (E, F) body dorsal view. (G) body, lateral view. (H, I) genitalia, ventral view. (J, K) genitalia, dorsal view. Type specimen: Male, (L) body, dorsal view; (M) genitalia, ventral view; (N) museum label of type specimen. Scale line 1 mm (A–G), 0.1 mm (H–M).

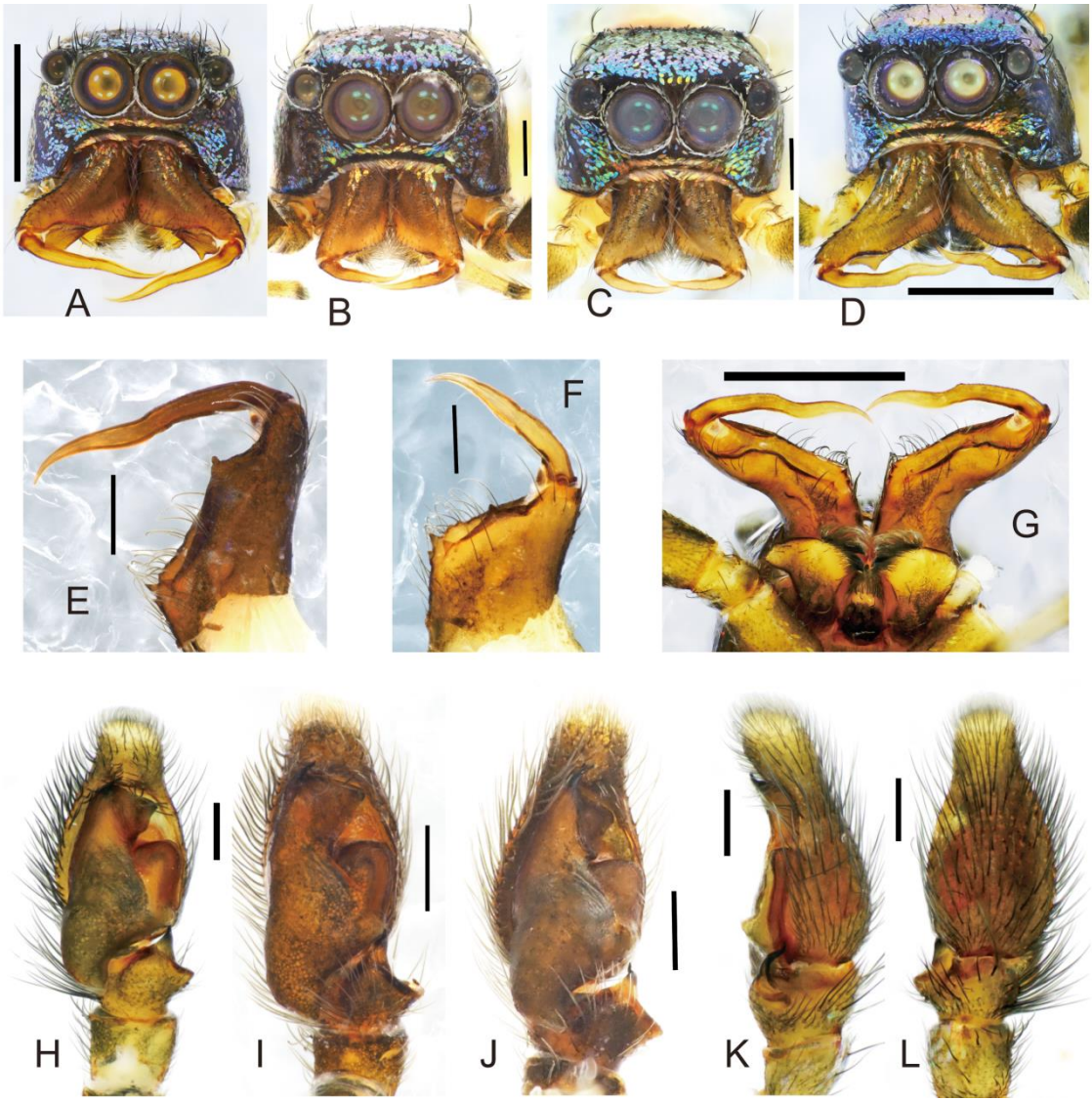

Figure 4.13. *P. vittata* from Vietnam. Male. (A–D) prosoma, frontal view. (E–G) chelicera and fang, ventral view. (H–J) palp, ventral view. (K) palp, retrolateral view. (L) palp, dorsal view. Scale line 1 mm (A, D, G), 0.3 mm (B–C), 0.2 mm (E–F, H–N).

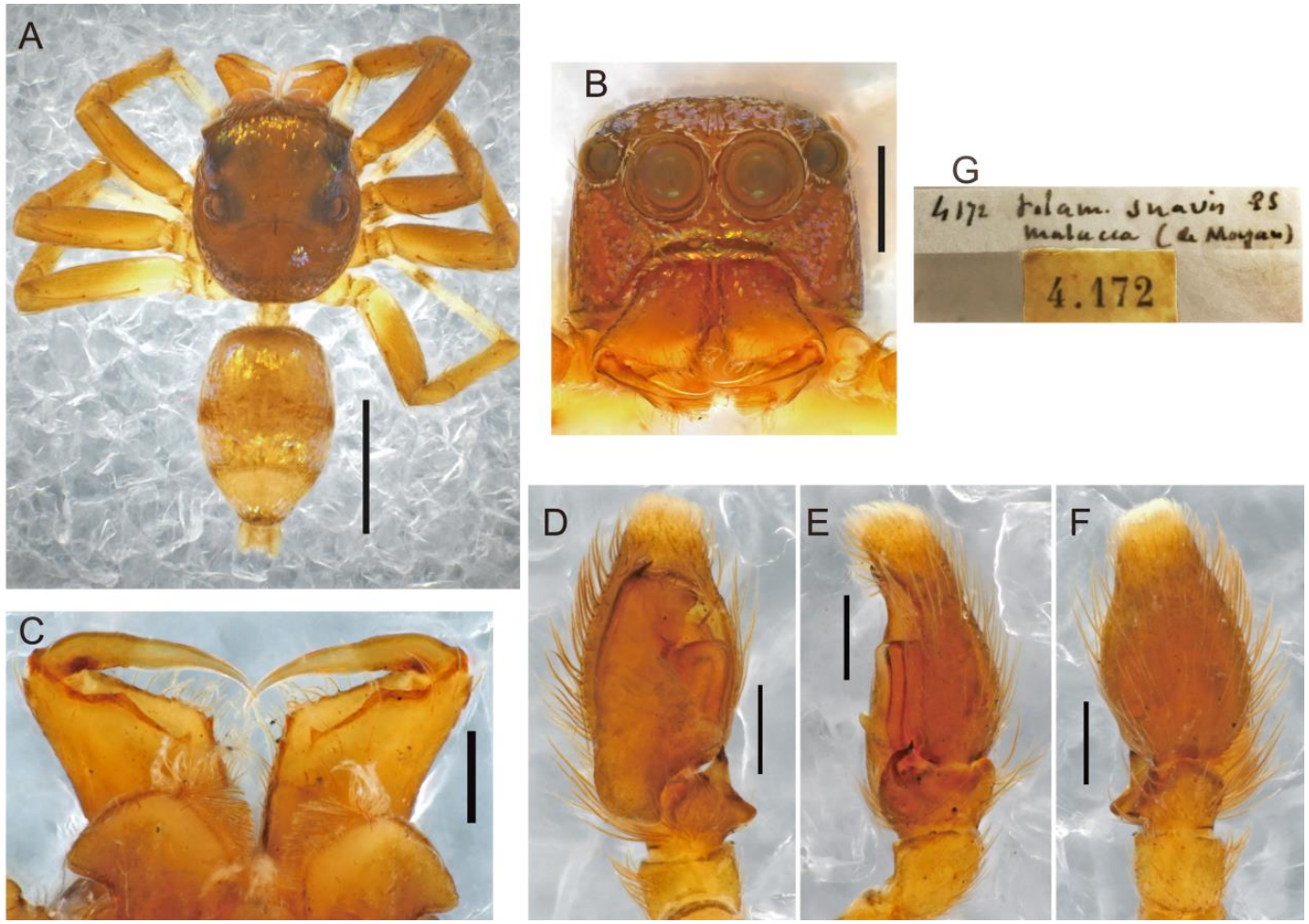

Figure 4.14. Type specimen of *P. suavis*. Male. (A) body, dorsal view. (B) prosoma, frontal view. (C) chelicera and fang, ventral view. (D) palp, ventral view. (E) palp, retrolateral view. (F) palp, dorsal view. Scale line 1 mm (A), 0.5 mm (B), 0.2 mm (C–F).

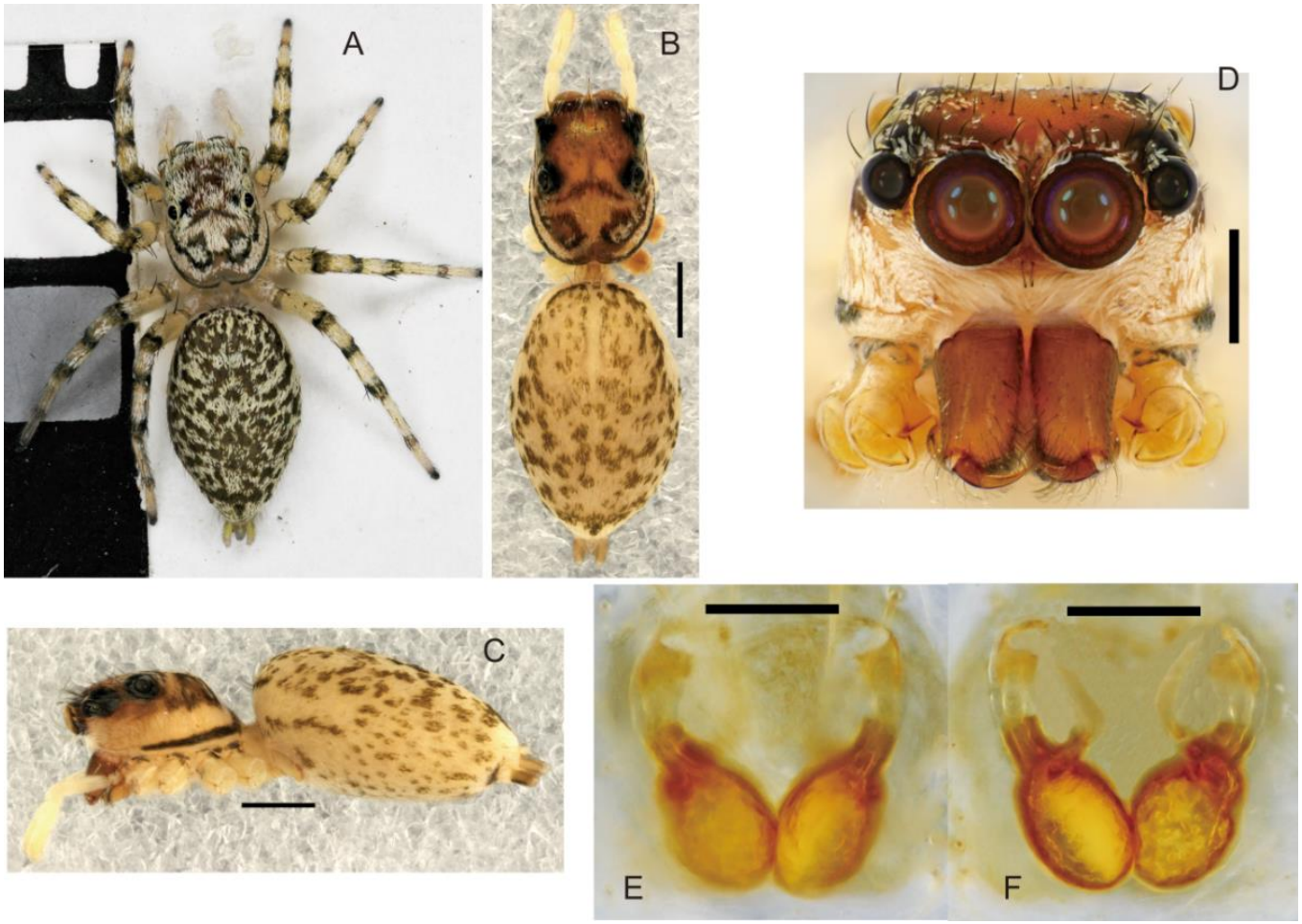

Figure 4.15. *P.* sp. 1 Female. (A, B) body dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) genitalia, ventral view. (F) genitalia, dorsal view. Scale line 1 mm (A–C), 0.5 mm (D), 0.1 mm (E–F).

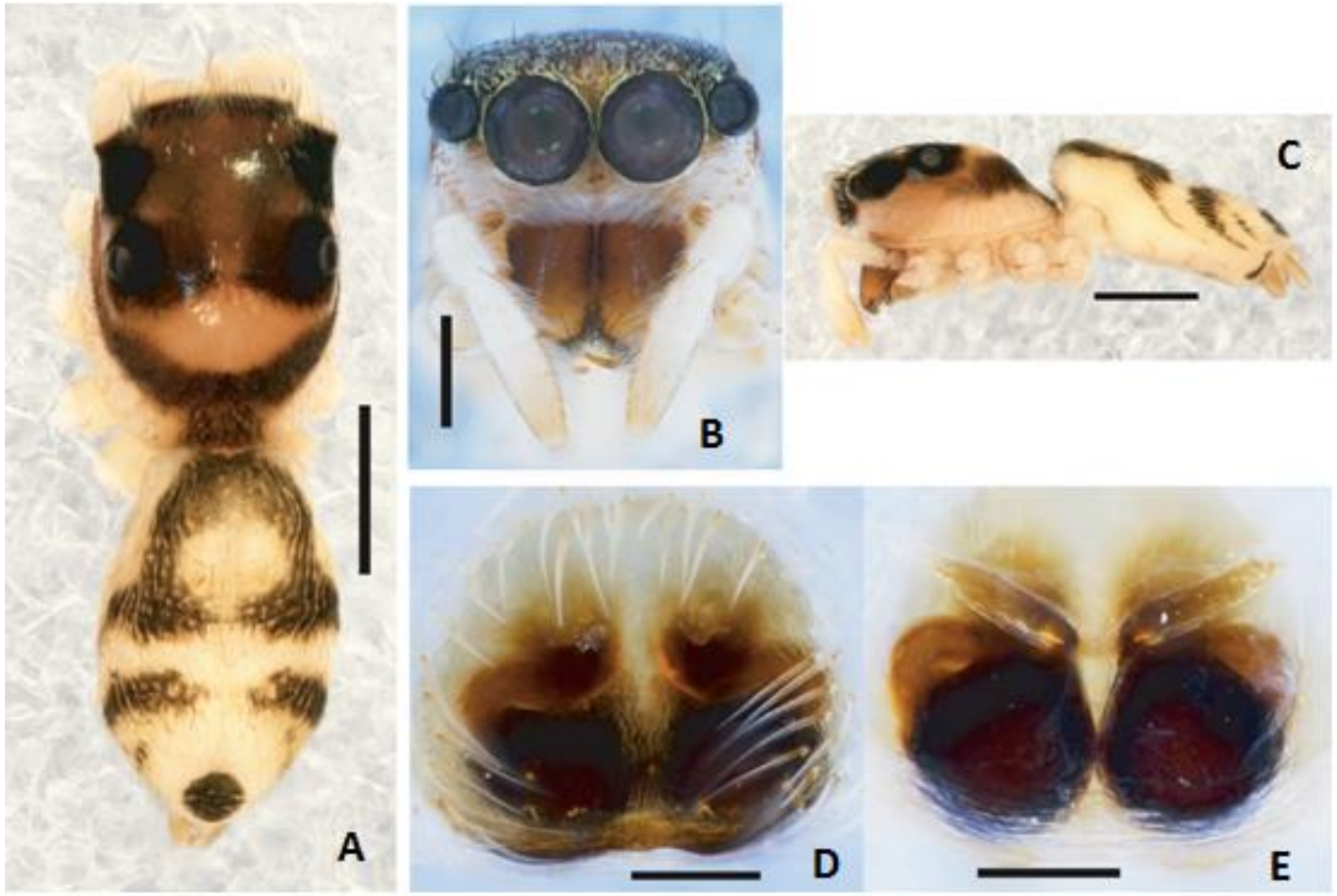

Figure 4.16. *P.* sp. 2 Female. (A) body dorsal view. (B) prosoma, frontal view. (C) body, lateral view. (D) genitalia, ventral view. (E) genitalia, dorsal view. Scale line 1 mm (A, C), 0.5 mm (B), 0.1 mm (D–E).

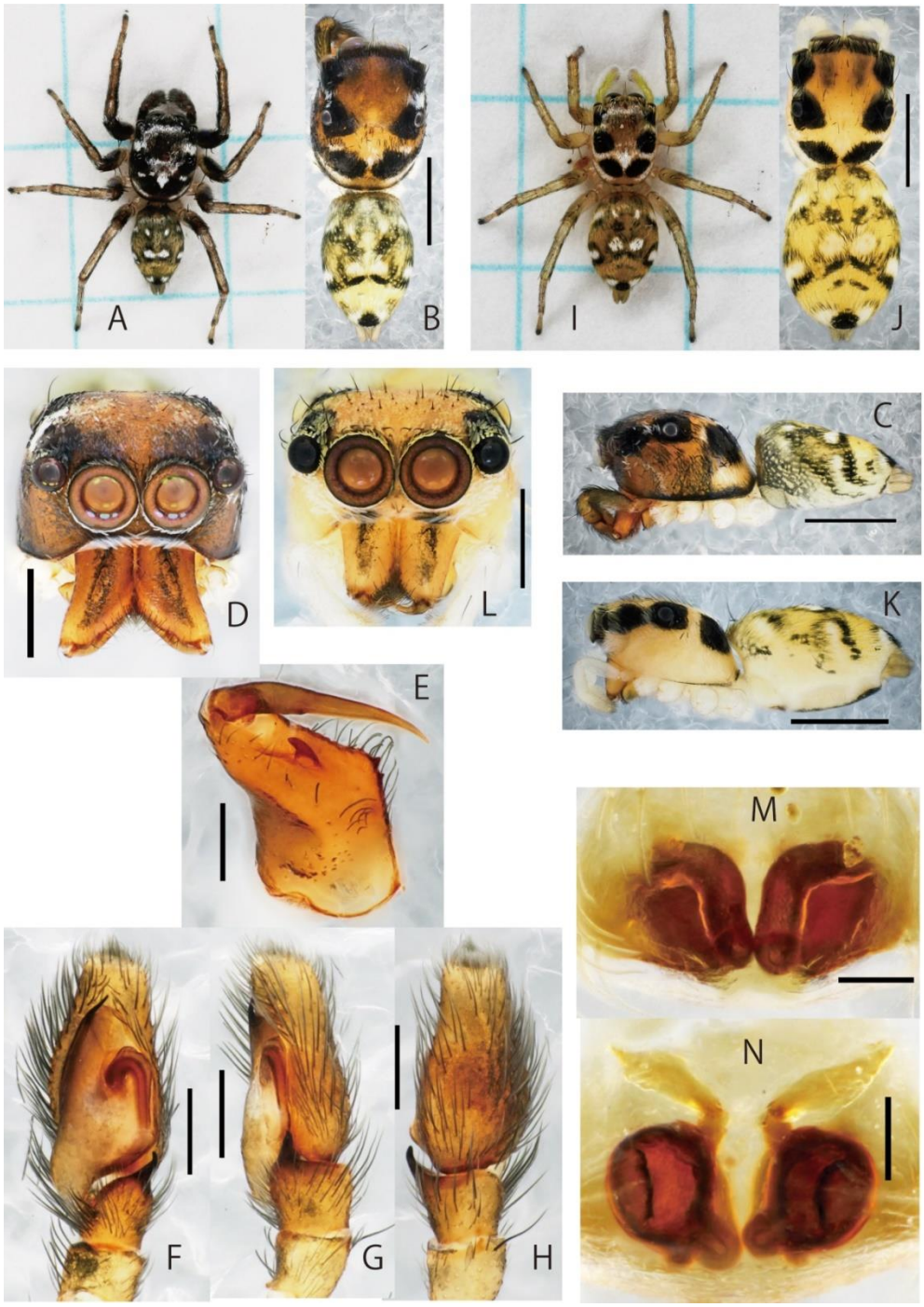

Figure 4.17. *P.* sp. 3 from Vietnam. Male (A–H), Female (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, L), 0.2 mm (E–H), 0.1 mm (M-N).

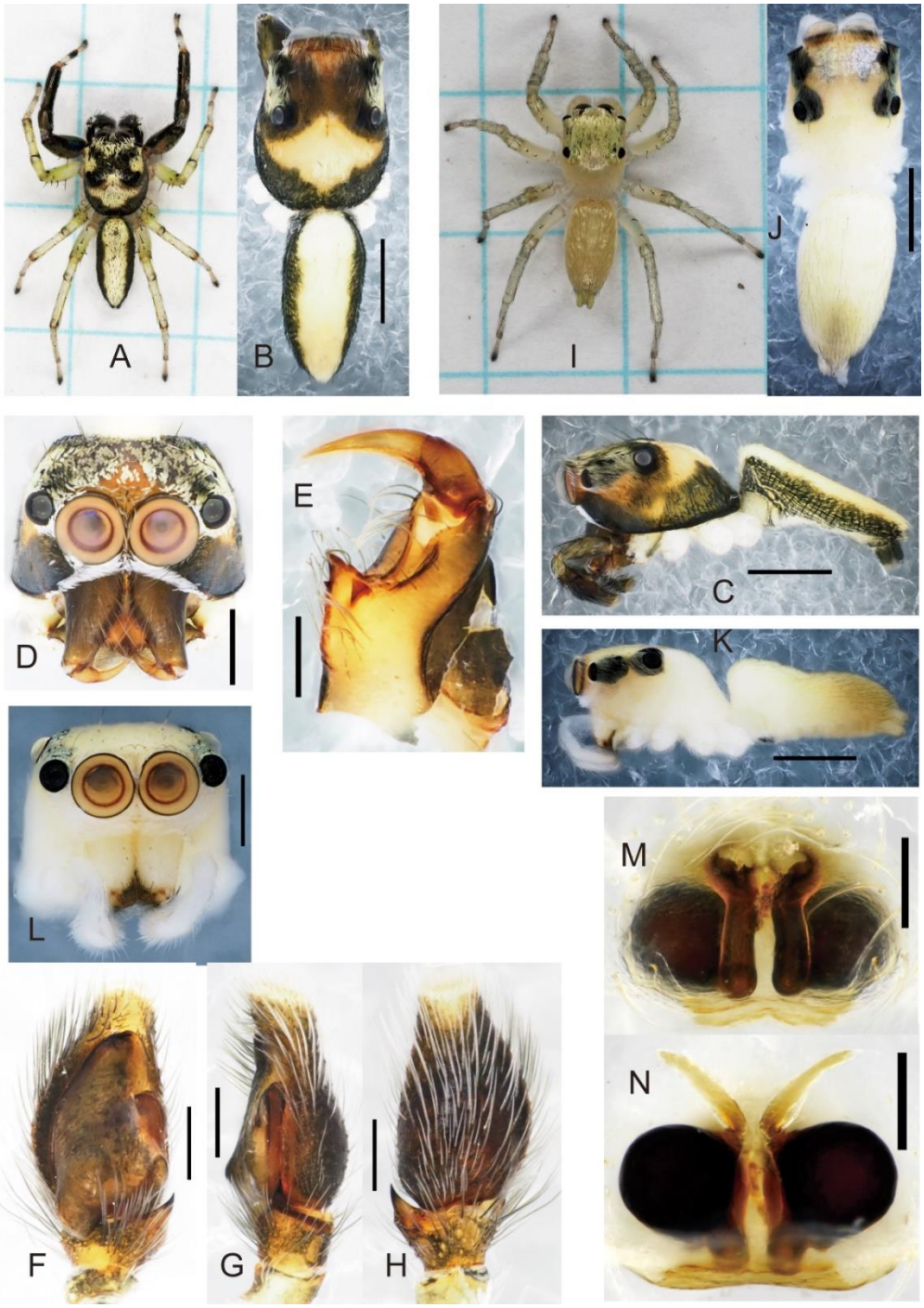

Figure 4.18. *P.* sp. 4 from Vietnam. Male (A–H), Female (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, L), 0.2 mm (E–H), 0.1 mm (M–N).

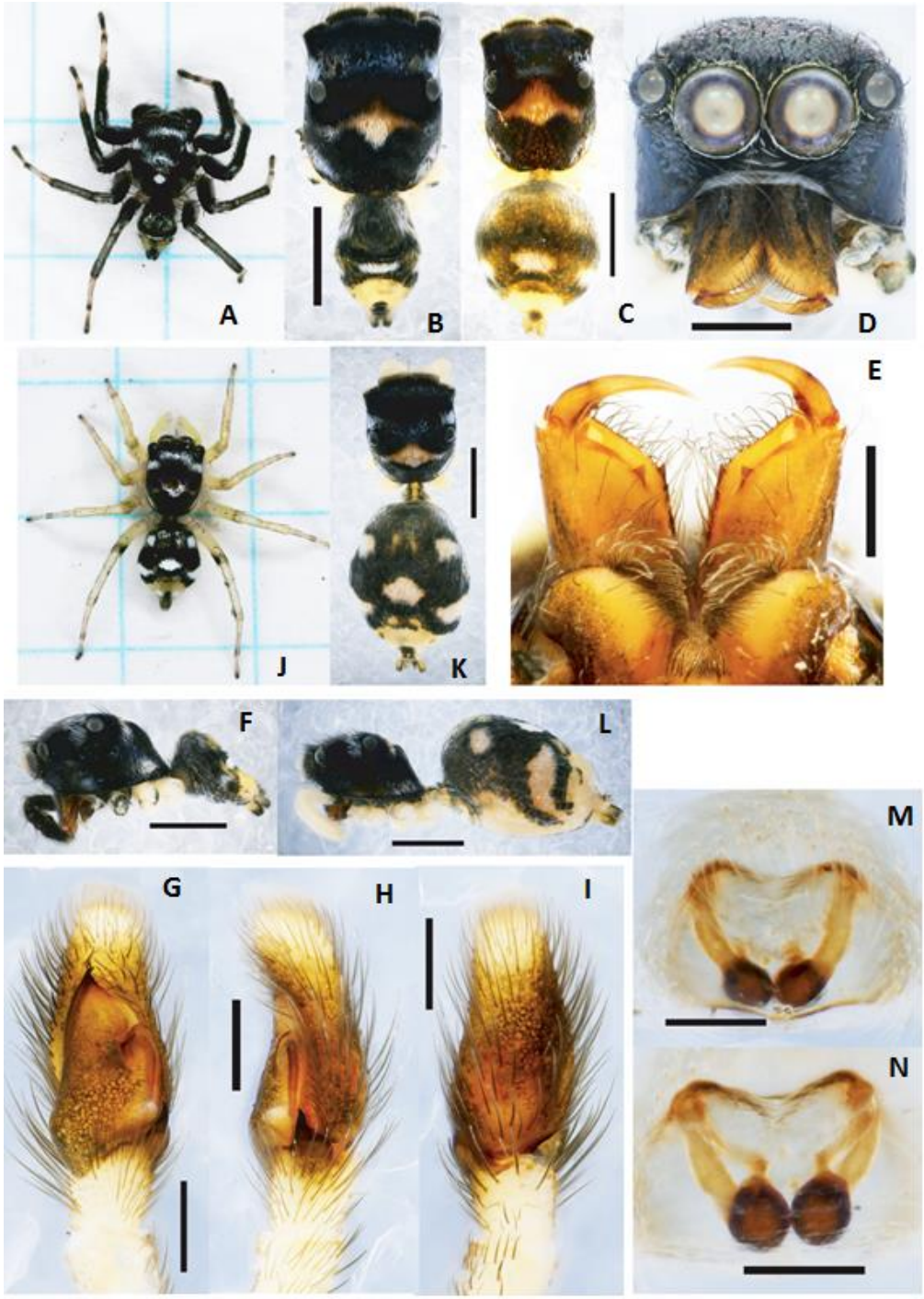

Figure 4.19. *P.* sp. 5 from Vietnam. Male (A–I), Female (J–N). (A, B, C) body, dorsal view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) body, lateral view. (G) palp, ventral view. (H) palp, retrolateral view. (I) palp, dorsal view. (J, K) body dorsal view. (L) body, lateral view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–C, F, J–L), 0.5 mm (D), 0.2 mm (E, G–I), 0.1 mm (M–N).

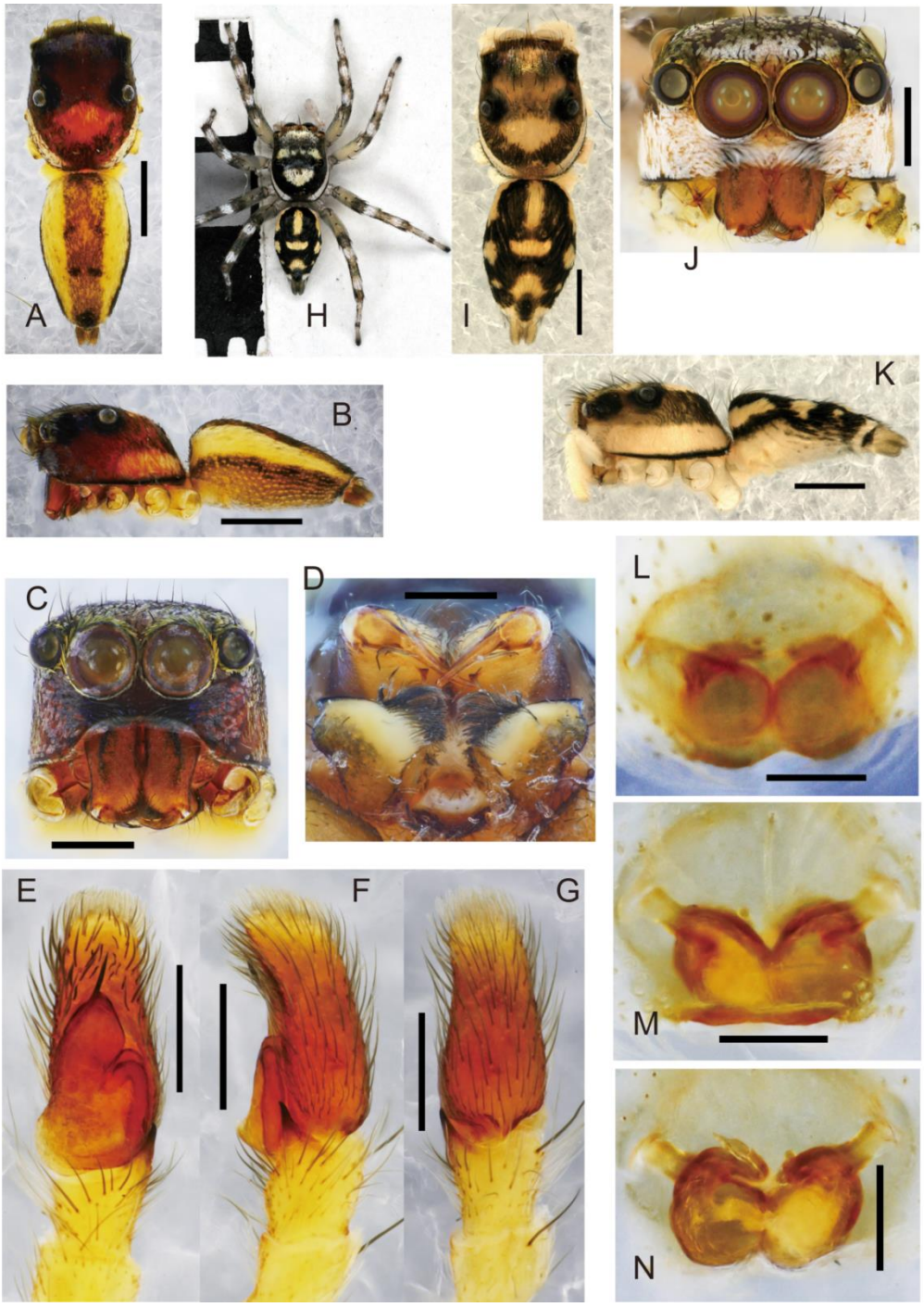

Figure 4.20. *P.* sp. 6 from Vietnam. Male (A–G), Female (H–N). (A) body, dorsal view. (B) body, lateral view. (C) prosoma, frontal view. (D) chelicera and fang, ventral view. (E) palp, ventral view. (F) palp, retrolateral view. (G) palp, dorsal view. (H, I) body dorsal view. (K) body, lateral view. (J) prosoma, frontal view. (L, M) genitalia ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–B, H–K), 0.5 mm (C, J), 0.3 mm (D–G), 0.1 mm (L–N).

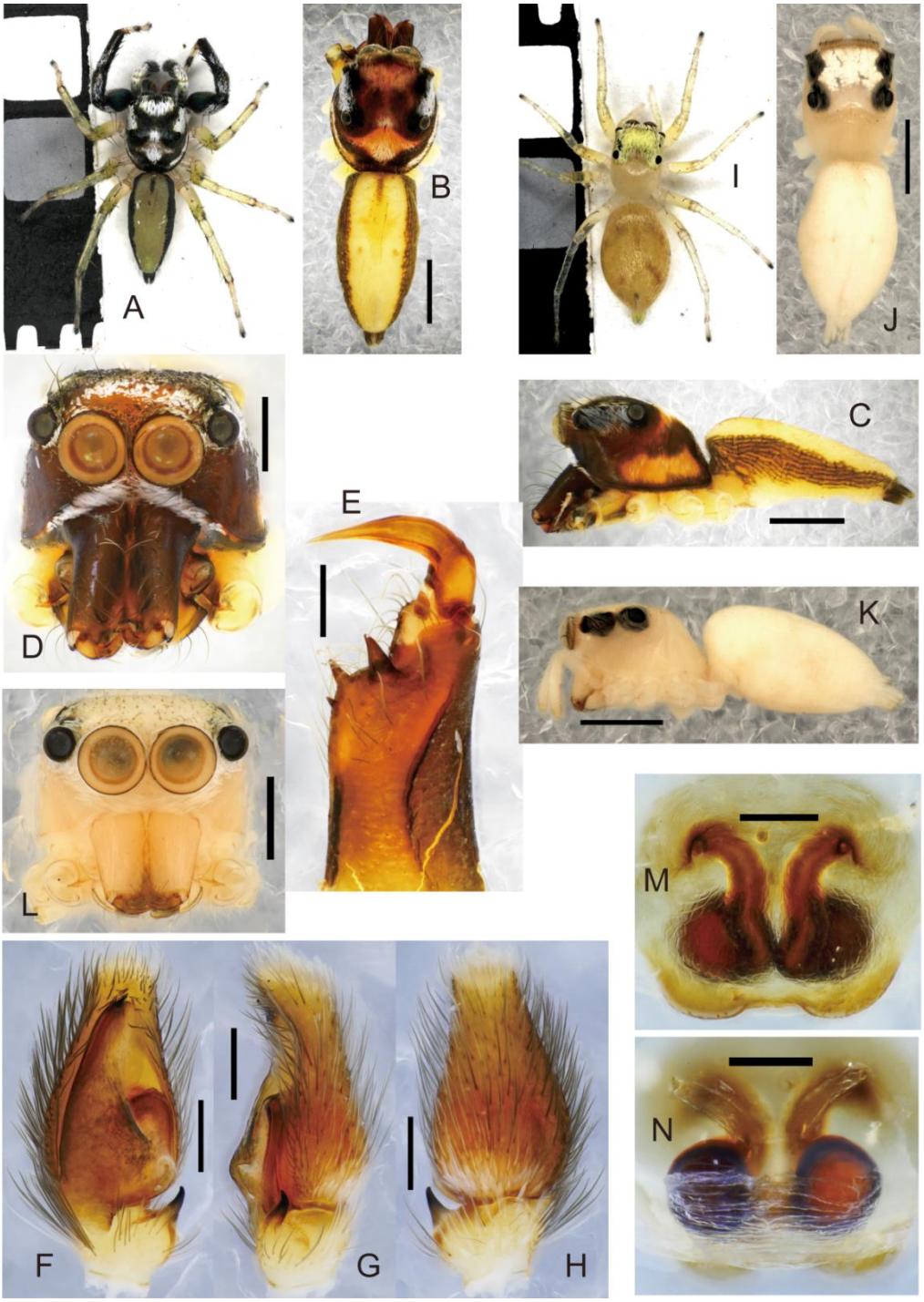

Figure 4.21. *P.* sp. 7 from Vietnam. Male (A–H), Female (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia, ventral view. (N) genitalia, dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, L), 0.2 mm (E–H), 0.1 mm (M–N).

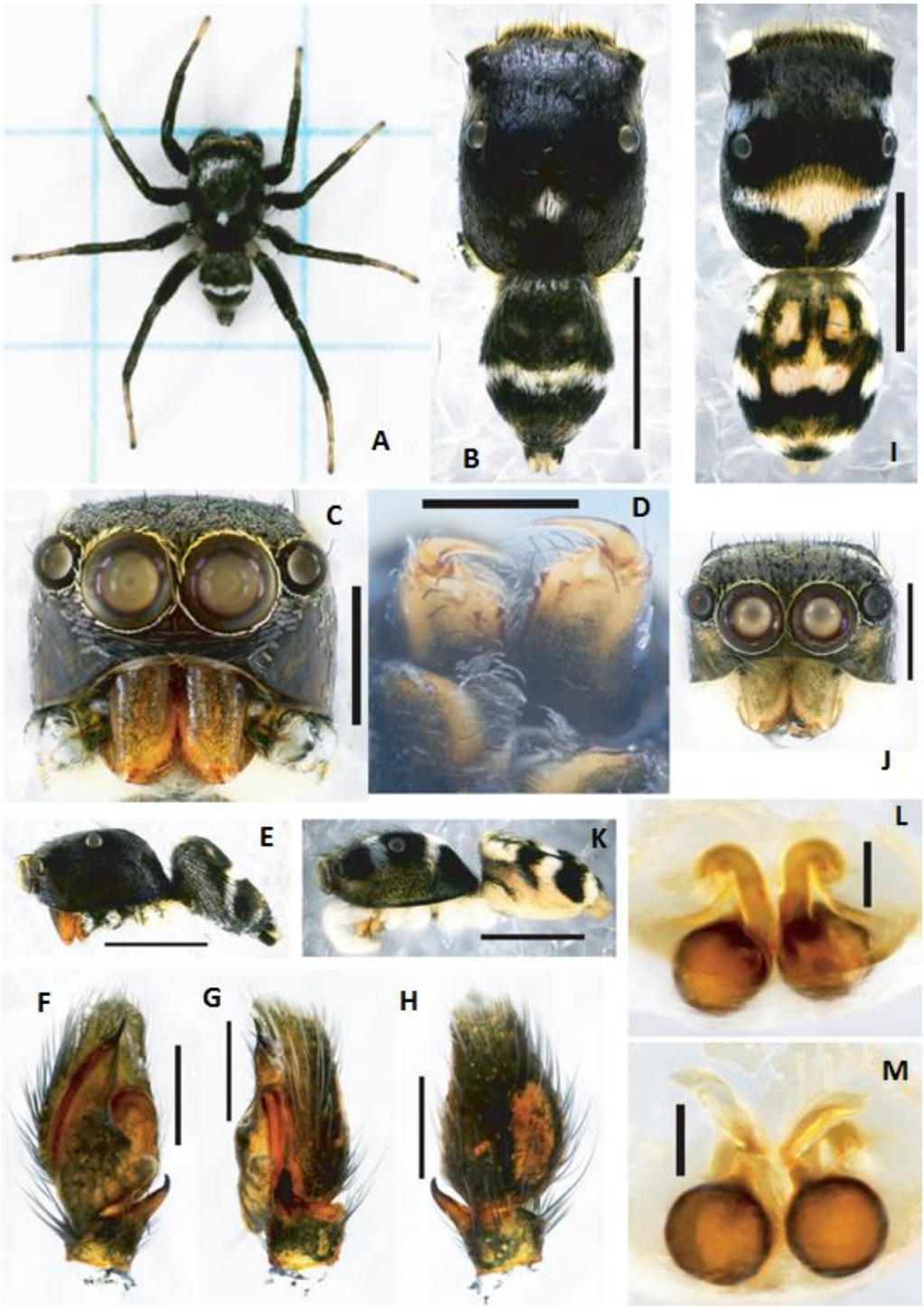

Figure 4.22. *P.* sp. 8 from Vietnam. Male (A–H), Female (I–M). (A–B) body, dorsal view. (E) body, lateral view. (C) prosoma, frontal view. (D) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp, retrolateral view. (H) palp, dorsal view. (I) body, dorsal view. (K) body, lateral view. (J) prosoma, frontal view. (L) genitalia, ventral view. (M) genitalia, dorsal view. Scale line 1 mm (A–B, E, I, K), 0.5 mm (C, J), 0.3 mm (D), 0.2 mm (F–H), 0.1 mm (L–M).

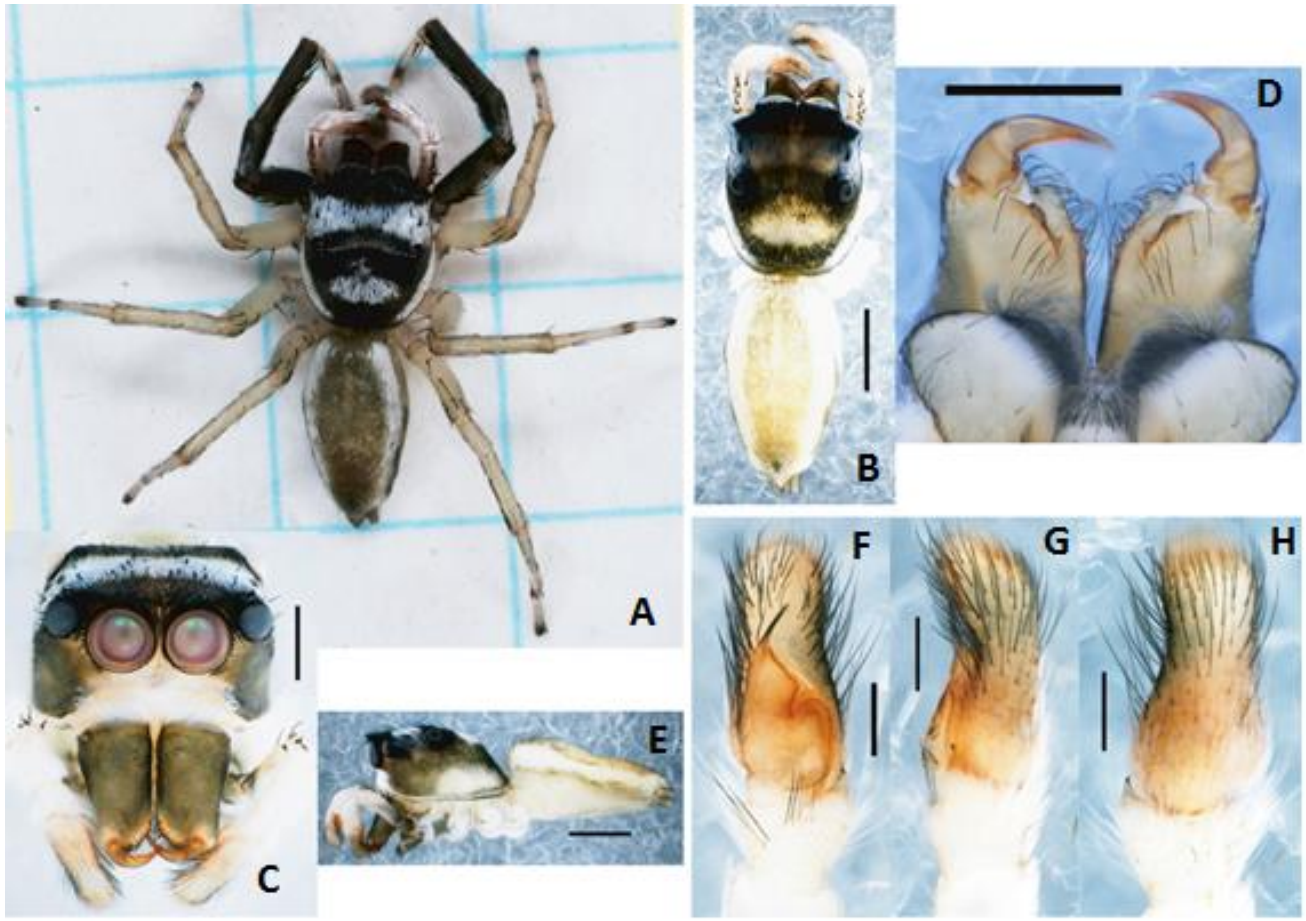

Figure 4.23. *P.* sp. 9 from Vietnam. Male. (A–B) body, dorsal view. (C) prosoma, frontal view. (D) chelicera and fang, ventral view. (E) body, lateral view (F) palp, ventral view. (G) palp retrolateral view. (H) palp dorsal view. Scale line 1 mm (A–B, E), 0.5 mm (C–D), 0.2 mm (F–H).

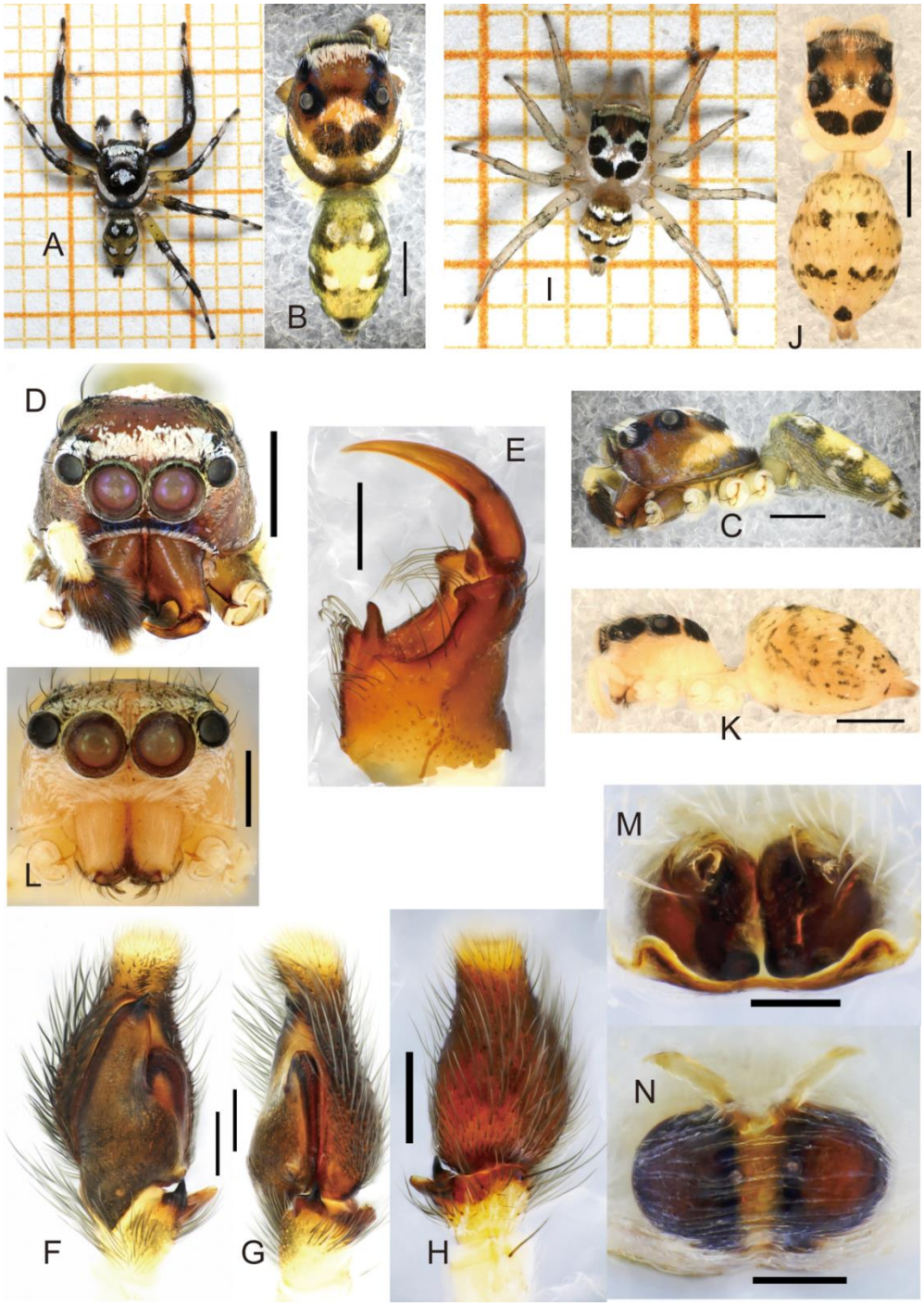

Figure 4.24. *P.* sp. 10 from Vietnam. Male (A–H), Female. (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp retrolateral view. (H) palp dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia ventral view. (N) genitalia dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, L), 0.3 mm (E), 0.2 mm (F–H), 0.1 mm (M–N).

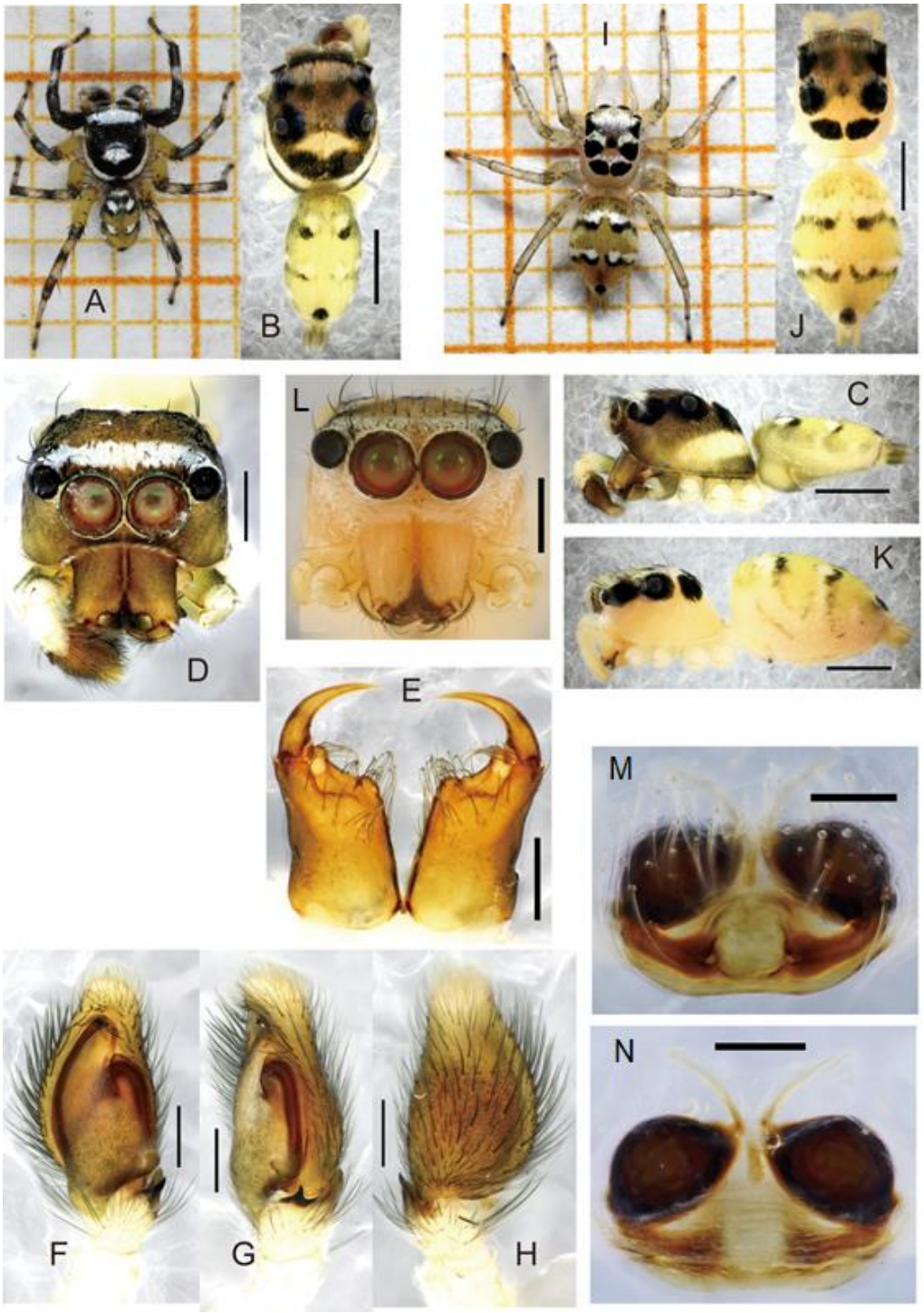

Figure 4.25. *P.* sp. 11 from Vietnam. Male (A–H), Female. (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp retrolateral view. (H) palp dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia ventral view. (N) genitalia dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, L), 0.3 mm (E), 0.2 mm (F–H), 0.1 mm (M–N).

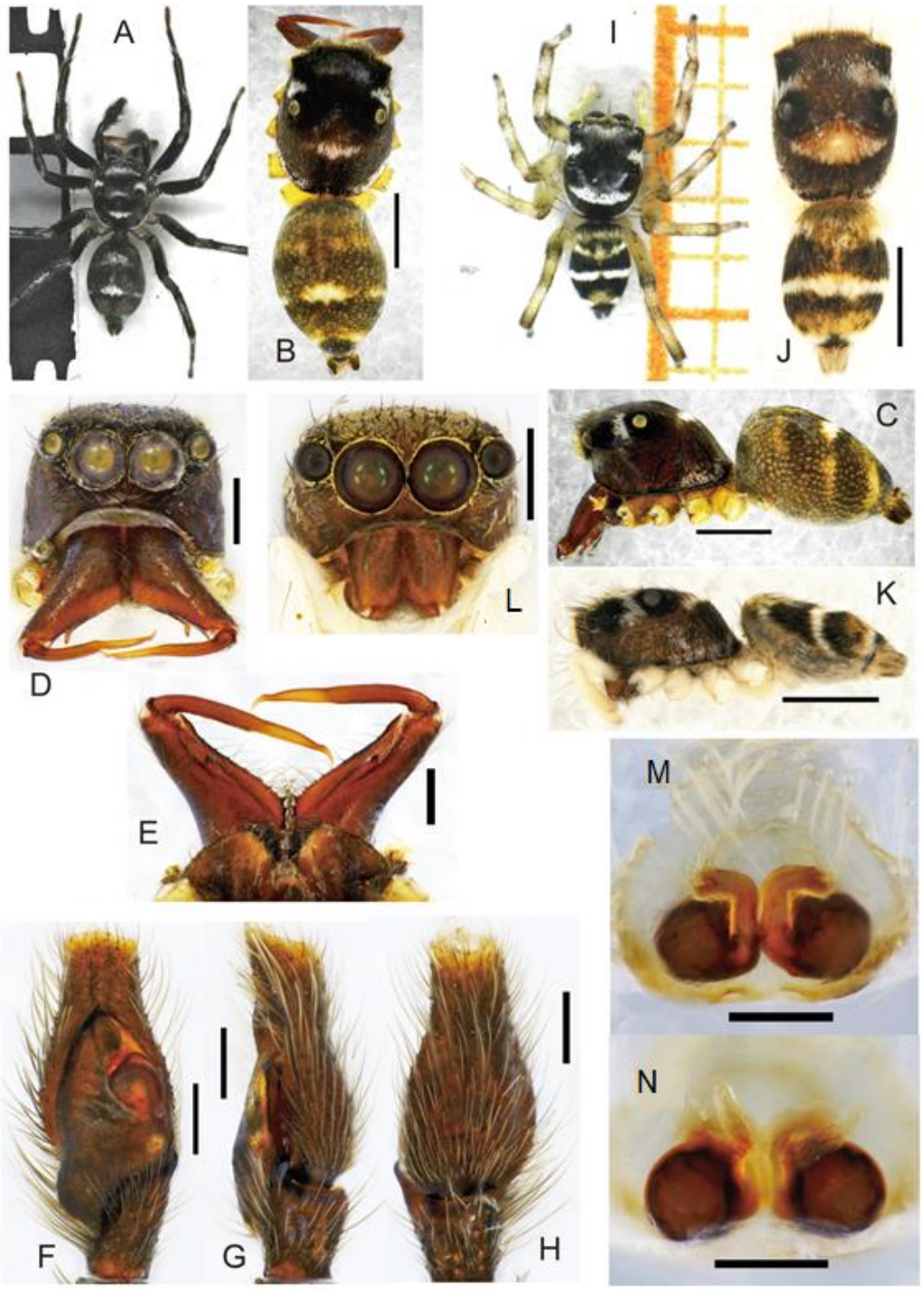

Figure 4.26. *P.* sp. 12 from Vietnam. Male (A–H), Female. (I–N). (A–B) body, dorsal view. (C) body, lateral view. (D) prosoma, frontal view. (E) chelicera and fang, ventral view. (F) palp, ventral view. (G) palp retrolateral view. (H) palp dorsal view. (I, J) body dorsal view. (K) body, lateral view. (L) prosoma, frontal view. (M) genitalia ventral view. (N) genitalia dorsal view. Scale line 1 mm (A–C, I–K), 0.5 mm (D, L), 0.3 mm (E), 0.2 mm (F–H), 0.1 mm (M–N).

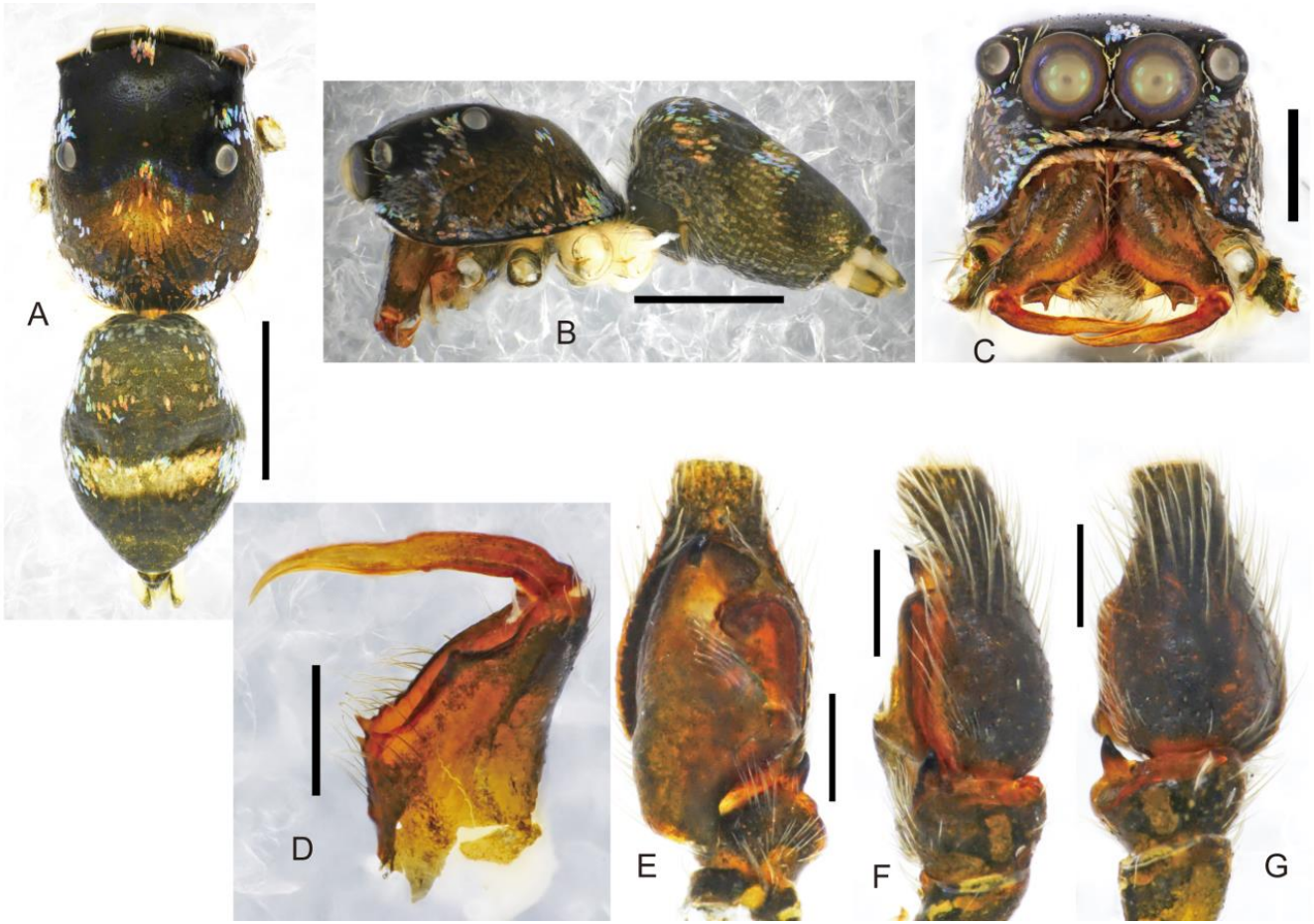

Figure 4.27. *P.* sp. 13 from Vietnam. Male. (A) body, dorsal view. (B) body, lateral view. (C) prosoma, frontal view. (D) chelicera and fang, ventral view. (E) palp, ventral view. (F) palp, retrolateral view. (G) palp, dorsal view. Scale line 1 mm (A–B), 0.5 mm (C), 0.3 mm (D), 0.2 mm (E–G).

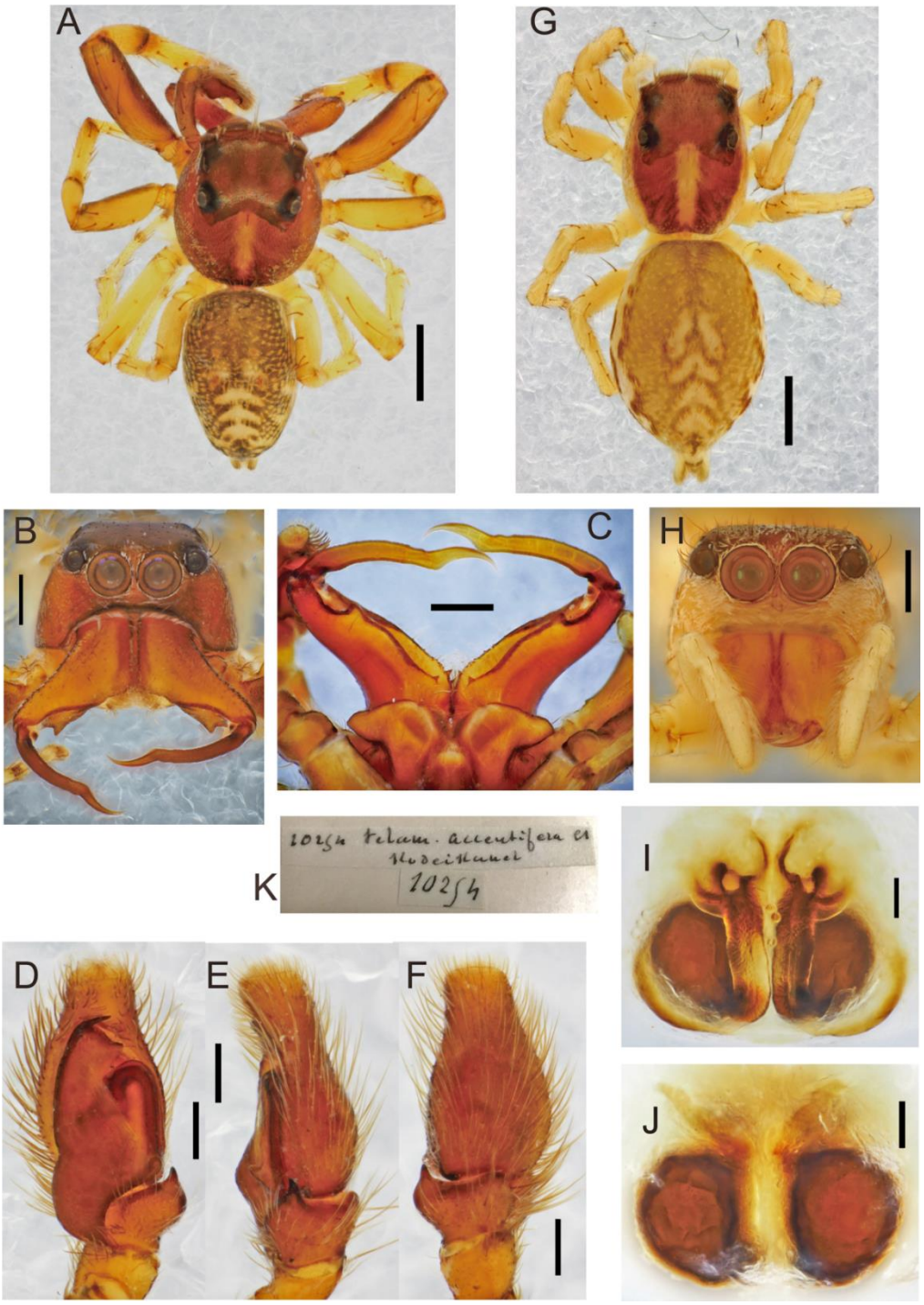

Figure 4.28. *P. accentifera* (Type specimen). Male (A–F), Female. (G–J). (A) body, dorsal view. (B) prosoma, frontal view. (C) chelicera and fang, ventral view. (D) palp, ventral view. (E) palp, retrolateral view. (F) palp, dorsal view. (G) body, dorsal view. (H) prosoma, frontal view. (I) genitalia, ventral view. (J) genitalia, dorsal view. Scale line 1 mm (A, G), 0.5 mm (B–C, H), 0.2 mm (D–F), 0.05 mm (I–J).

Chapter 5

GENERAL DISCUSSION

5.1. Distribution pattern of Vietnamese *Phintella*

Of the 23 species recognized from Vietnam, 22 species have an Oriental and Palearctic distribution. However, only one species, *P. monteithi*, was previously known only from the Australian region (Fig. 5.1), thus the species may be actually widespread in Southeast Asia. *Phintella debilis* is most widespread; *P. cavaleriei* and *P. versicolor* is distributed mainly in the Palearctic region, and the boundary of the Oriental and Palearctic regions; *P. vittata* mainly in the Oriental region, and the boundary of the Oriental and Palearctic regions; *P. accentifera* was found in Southern China and N. Vietnam, and India (however, the conspecificity of the two remote populations needs to be confirmed by integrated taxonomy). *Phintella aequipeiformis* and *P. squamata* has so far been known from Southern China and Northern Vietnam (Song *et al.*, 1999; Yin *et al.*, 2012; the present study). *Phintella lepidus* and *P. sancha* have so far been known from Southern China (Song *et al.*, 1999; Yin *et al.*, 2012) but also from Southern Vietnam (the present study), thus the two species may be actually widespread in other parts of Vietnam and adjacent areas. Thirteen new species were found from Vietnam, however, intensive sampling in surrounding areas will be needed to establish their geographic ranges.

As mention in the Chapter 1 (Section 1.4), a variety of local climate regimes in Vietnam can be grouped into two main regional climates: Northern Climate Regime (from Chinese border south to 18˚N – around Deo Ngang Pass in Ha Tinh province) and Southern Climate Regime (Tay Nguyen Plateau or West Truong Son and Southern Vietnam with Mekong River delta) (Le, 1997). The biota of Northern Climate Regime are similar to that of Southern China and South-eastern foothills of the Himalayas, and the vegetation of Southern Vietnam shares its dry deciduous forests and peat swamp communities with lowland vegetation of Southeast Asian mainland and the Malay Archipelago (Sterling *et al.*, 2006). The distribution patterns of *Phintella* inside Vietnam

roughly correspond to this bio-climate zoning. Of the 23 *Phintella* species recorded from Vietnam, three species (*P. debilis, P. versicolor* and *P. vittata*) were distributed throughout Vietnam (Fig. 5.2); 10 species (*P. accentifera, P. aequipeiformis, P. cavaleriei, P. squamata*, *P*. sp. 1, *P.* sp. 2, *P*. sp. 3, *P*. sp. 6, *P*. sp. 12 and *P*. sp. 13) were found in the Northern Climatic Regime (Fig. 5.3); 5 species (*P. monteithi, P*. sp. 4, *P*. sp. 9, *P*. sp. 10 and *P*. sp. 11) in the Southern Climatic Regime (Fig. 5.4); 3 species (*P*. sp. 5, *P*. sp. 7 and *P*. sp. 8) were found in the transition region between the Northern and Southern Climatic Regimes, i.e., Truong Son Range in Central Vietnam (Fig. 5.5). Truong Son Range harbors many endemic species (Sterling *et al.*, 2006).

Although distributional data of *Phintella* spp. in the western part of the Indo-Chinese Peninsula has not yet been accumulated, the present study reveals that species composition of *Phintella* changes drastically between the two climatic regimes.

5.2. The scientific significances and the prospects of this study

One of the great achievements of the present study is the discovery of 13 new species of the genus *Phintella* in Vietnam. This demonstrates that the salticid diversity in the Oriental region is very high and suggests a vast number of species remain undiscovered. Sequences of newly recognized and described species are useful for updating phylogenetic hypotheses and higher classification. Therefore, continuing studies on species diversity of salticids in the Oriental region using integrated taxonomy should be encouraged.

As mentioned in Chaper 2, the conspecific male-female complementarity is difficult to be clarify by a traditional morphological approach because of the remarkable sexual dimorphism in morphology and coloration. The present study strongly demonstrates that the present integrated taxonomy approach (a combination of DNA barcoding, phylogenetic analyses, comparative morphological examination and biogeographical consideration) is especially powerful for revealing the conspecific male-female complementarity, and subsequently solving synonymies and/or unifying the male-based and female-based classifications, as well as for discovering cryptic species.

Interspecific and intraspecific K2P divergences calculated based on the COI dataset (Table 2.7) highlight a very clear barcode gap: intraspecific divergences ranging from

0 % to 2.22%; interspecific divergences from 4.40 to 17.47 (Chapter 2). Blagoev *et al*. (2016) revealed that the mean interspecific divergence between nearest–neighbor species (=sister species) was 10 times higher than the mean intraspecific divergence in Canadian spiders (7.85% vs. 0.78%), and 7 times higher in Canadian salticid spiders (7.57% vs. 1.18%). Other studies on various arthropod taxa including spiders (Hebert *et al.*, 2003 for Lepidoptera; Barrett & Hebert, 2005 for spiders; Smith *et al.*, 2005 for Formicidae; Robinson *et al.*, 2009 for spiders; Renaud *et al.*, 2012 for Diptera; Glowska *et al.*, 2014 for syringophilid mites; Doña *et al.*, 2015 for feather mites) suggested that the interspecific divergence values of COI are usually greater than 2–3%, or the intraspecific divergence values of COI are usually less than 2–3%. The results of the present integrated taxonomy fit very well with these previous results on terrestrial arthropods. Integrated taxonomy can not be applied to cases where only a small number of specimens is available. Therefore, the "2–5% threshold" should be useful as a "scale" for estimating whether multiple species are present in the small collection or not.

References

Blagoev G. A., deWaard J. R., Ratnasingham S., deWaard S. L., Lu L., Robertson J., Telfer A. C., Hebert D. N. 2016. Untangling taxonomy: a DNA barcode reference library for Canadian spiders. Molecular Ecology Resources 16: 325–341.

Doña J., Diaz-Real J., Mironov S., Bazaga P., Serrano D., Jovani R. 2015. DNA barcoding and minibarcoding as a powerful tool for feather mite studies. Molecular Ecology Resources 15: 1216–1225.

Glowska E., Dragun-Damian A., Broda L., Dabert J., Dabert M. 2014. DNA barcodes reveal female dimorphism in syringophilid mites (Actinotrichida: Prostigmata: Cheyletoidea): Stibarokris phoeniconaias and Ciconichenophilus phoeniconaias are conspecifi c. Folia Parasitologica 61: 272–276.

Hebert P. D. N., Cywinska A., Ball S. L., deWaard J. R. 2003. Biological identifi cations through DNA barcodes. Proceedings of the Royal Society of London. Series B: Biological Sciences 270: 313–321.

Renaud A. K., Savage J., Adamowicz S. J. 2012. DNA barcoding of Northern Nearctic Muscidae (Diptera) reveals high correspondence between morphological and molecular species limits. BMC Ecology 12: 24.

Robinson E. A., Blagoev G. A., Hebert P.D.N., Adamowicz, S.J. 2009. Prospects for using DNA barcoding to identify spiders in species–rich genera. ZooKeys 16: 27–46.

Simon E. 1899. Contribution à la faune de Sumatra. Arachnides recueillis par M. J. L. Weyers, à Sumatra. (Deuxiéme mémoire). Annales de la Société Entomologique de Belgique 43: 78–125.

Song D. X., Zhu M. S. & Chen J. 1999. The Spiders of China. Hebei University of Science and Techology Publishing House, Shijiazhuang 640 pp.

Smith M. A., Fisher B. L., Hebert P. D. N. 2005. DNA barcoding for effective biodiversity assessment of a hyperdiverse arthropod group: the ants of Madagascar. Philosophical Transactions of the Royal Society B 360: 1825–1834.

Sterling E. J, Hurley. M. M & Le M. D. 2006. Vietnam: a national history. Yale University Press. New Haven and London 444 pp.

Yin C. M., Peng, X. J., Yan, H. M., Bao, Y. H., Xu, X., Tang, G., Zhou, Q. S. & Liu, P. (2012). Fauna Hunan: Araneae in Hunan, China. Hunan Science and Technology Press, Changsha 1590 pp.

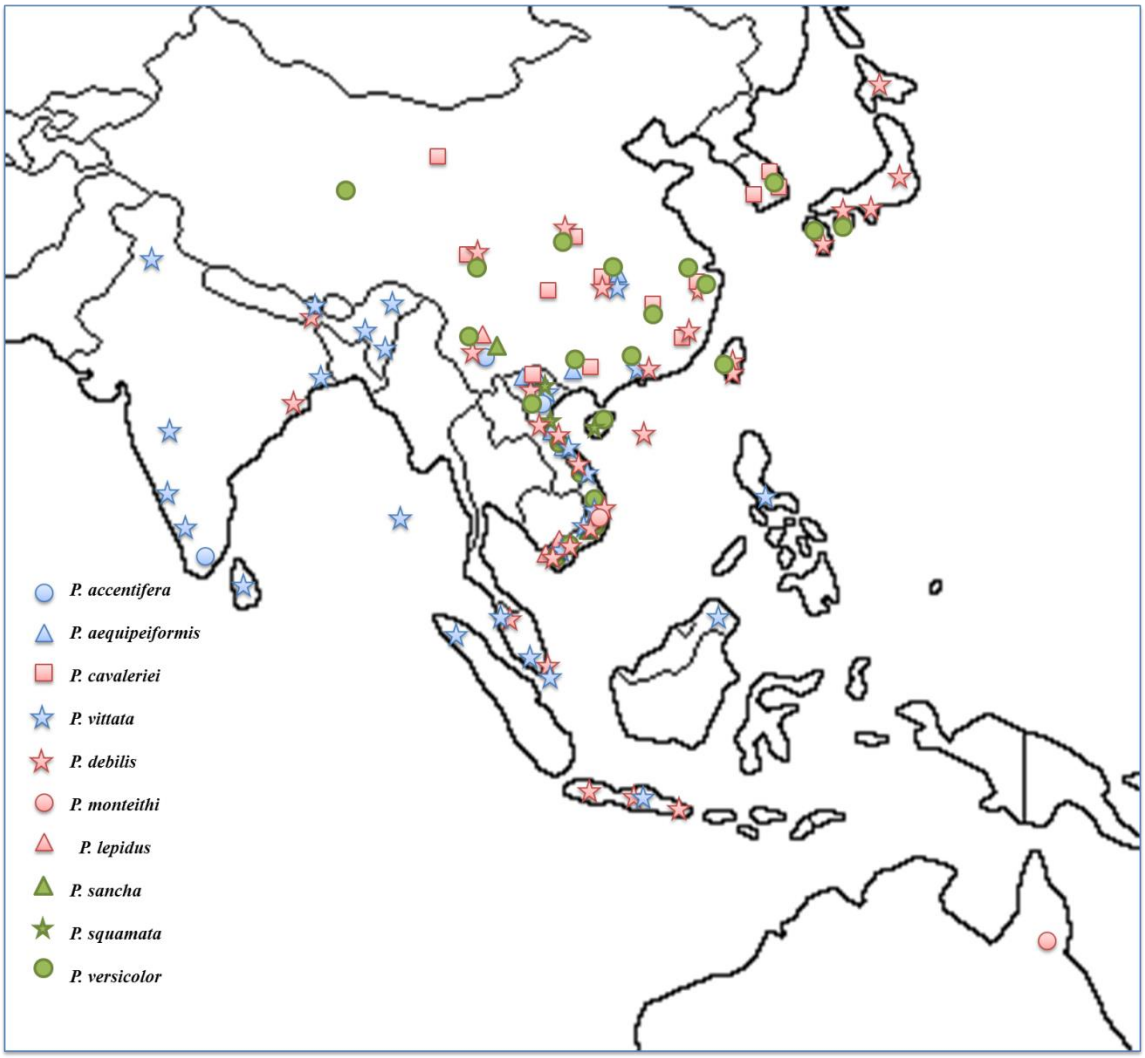

Figure 5.1. The known distribution of described species of the genus *Phintella* occurring in Vietnam

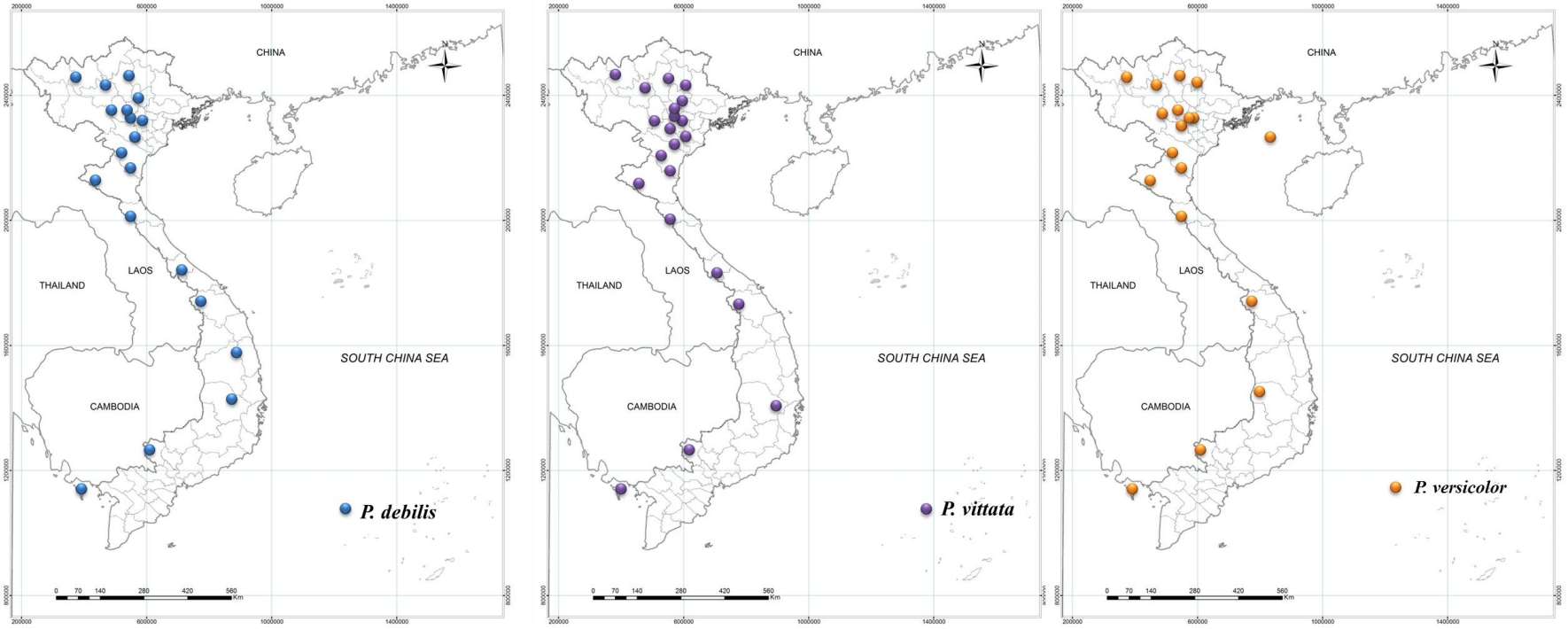

Figure 5.2. Collection records of *Phintella debilis, P. vittata* and *P. versivolor* in Vietnam

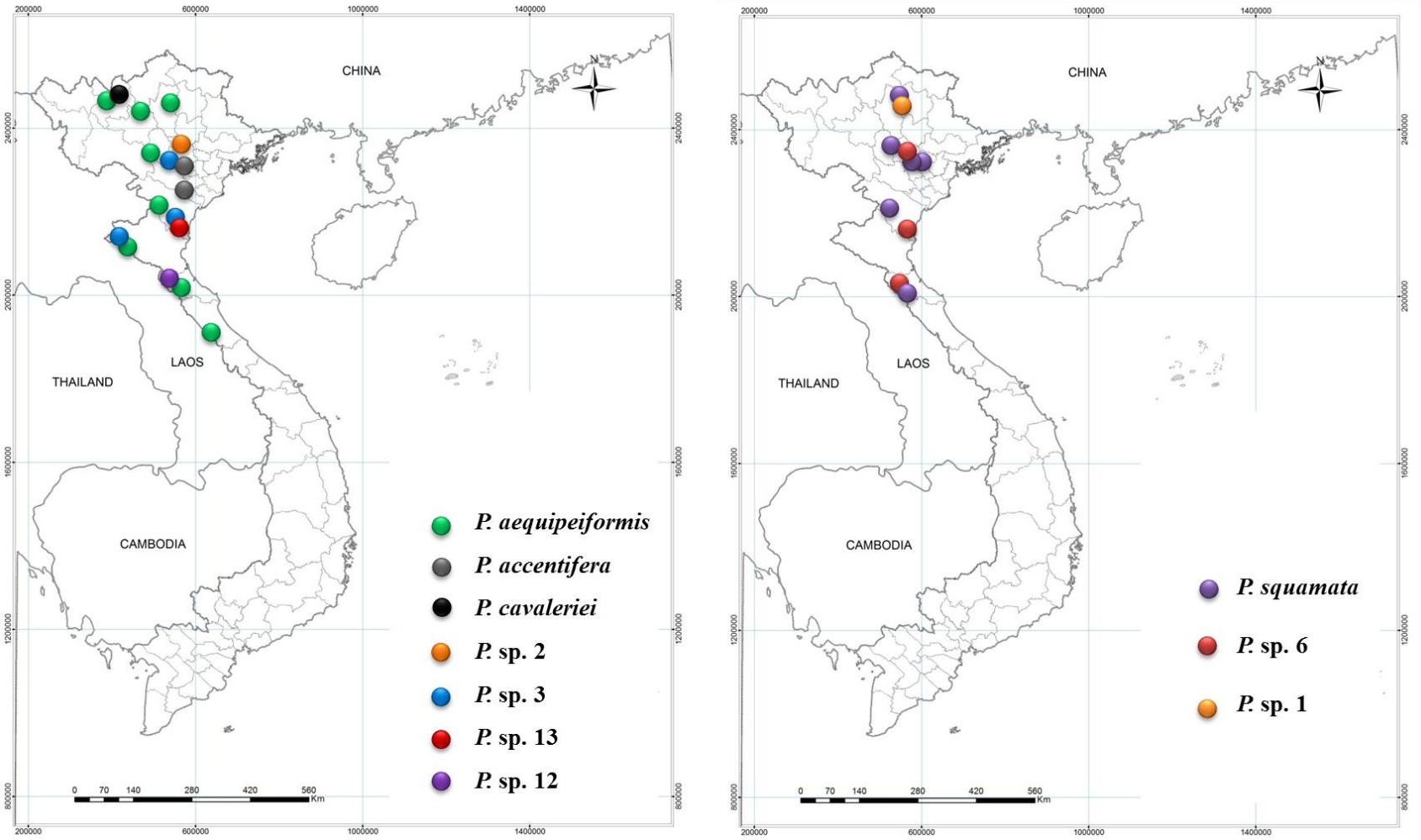

Figure 5.3. Collection records of Vietnam *Phintella* showing the "Northern Climatic Regime" distribution.

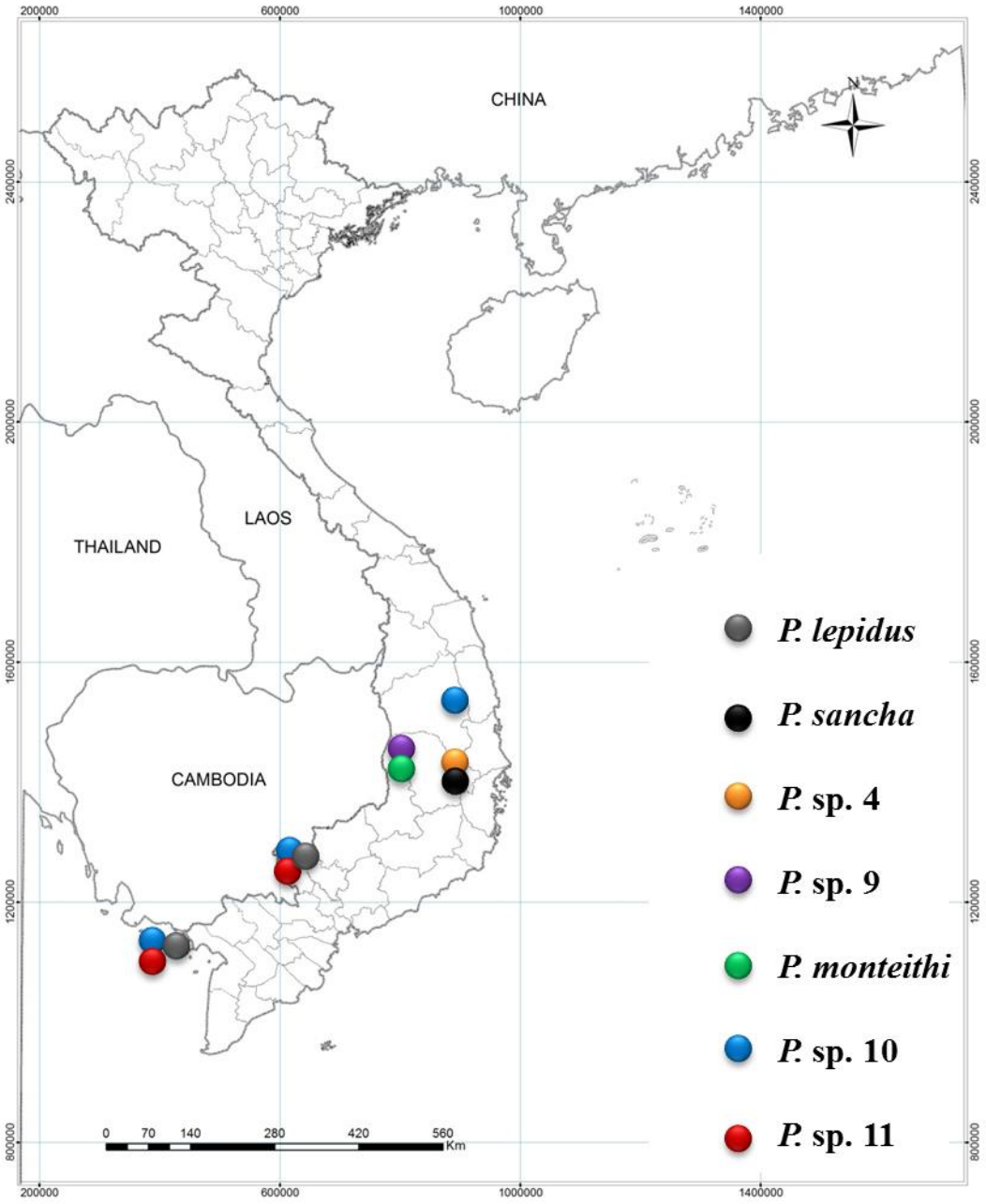

Figure 5.4. Collection records of Vietnam *Phintella* showing the "Southern Climatic Regime" distribution.

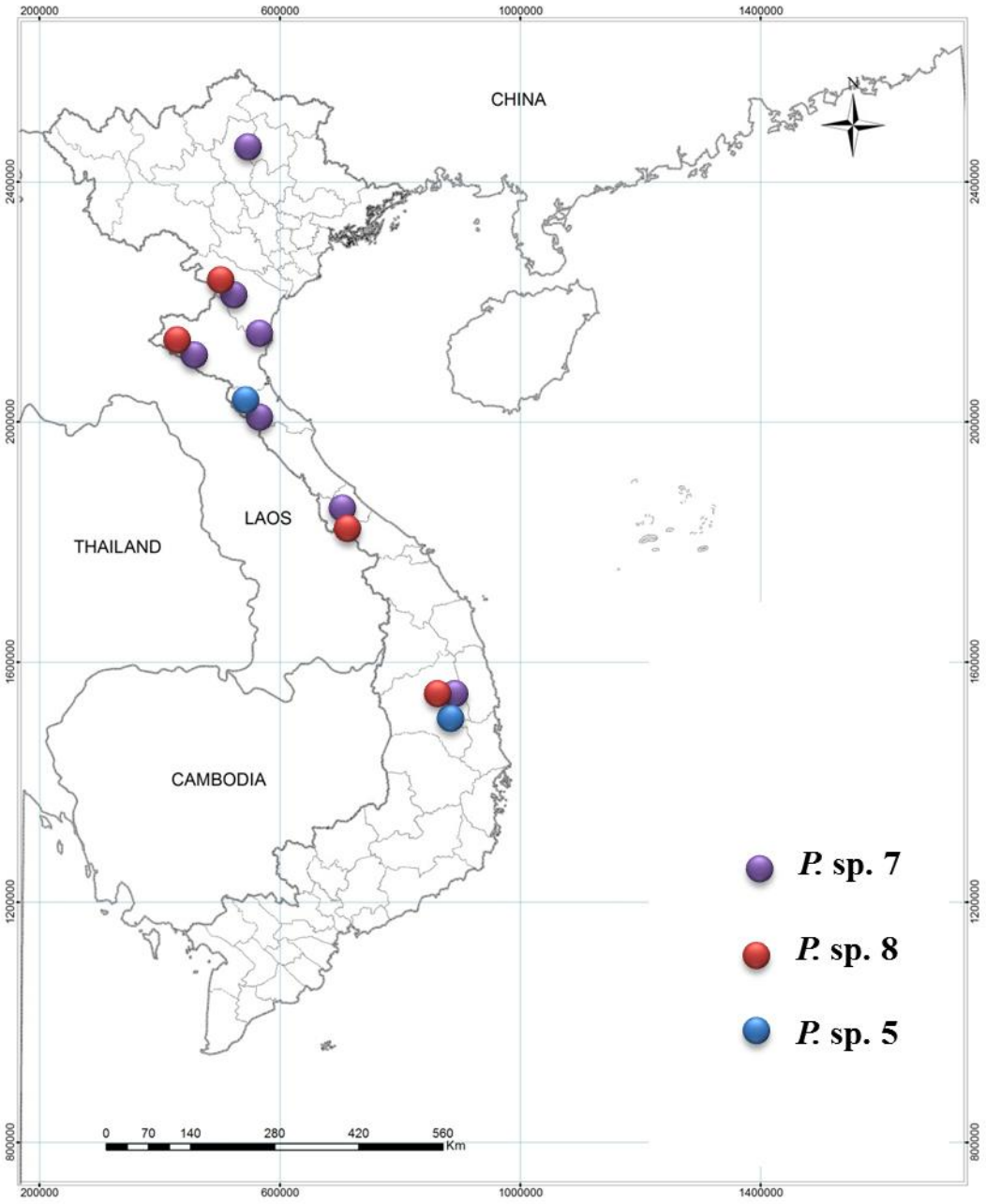

Figure 5.5. Collection records of *Phintella* sp. 5, *P.* sp. 7, and *P.* sp. 8 showing the "Truong Son Range" distribution.

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Appendices

Publications

Phung THL, Yamasaki T, Eguchi K. 2016. Conspecificity of *Phintella aequipeiformis* Zabka, 1985 and *P. lucai* Zabka, 1985 (Araneae: Salticiddae) confirmed by DNA barcoding. *Revue suisse de Zoologie* 123(2): 283–290.

Japanese summary

ベトナム産ヤマトハエトリグモ属（クモ目：ハエトリグモ科）の

分類学的再検討 （英文）

フオン テイ ホン ロン

クモ類（クモ目）は、陸上生態系において小型無脊椎動物の捕食者として優占的な分類群である。ハエトリグモ科はクモ目の中で最も種多様性が高い分類群であり、世界から 625 属約 6000 種（クモ目の総種数の約 13%）が知られる。ハエトリグモ科では、成体の形態や色彩に非常に顕著な性的二型が見られることが一般的である。そのため、一方の性のみしか知られていない種が少なくなく、シノニムが多数存在することが予想される。また、熱帯・亜熱帯地域において多数の未記載種が存在することも予想される。

Phintella 属はハエトリグモの中で種多様性が特に高い属の一つであり、その大半は東洋区と旧北区から知られている。しかしながら、インド−ビルマ生物多様性ホットスポットの中核をなすベトナムにおいて、*Phintella* 属の種多様性はほとんど解明されていない。そこで、本研究は、ハエトリグモ科の *Phintella* 属のベトナムに産する種の分類体系を再検討することを目的とした。前述の通り、成体の形態や色彩に彩に非常に顕著な性的二型が見られるため、61 種の既知種のうちの 13 種については雄が、14 種については雌が不明である。つまり、同種の雌雄の対応関係を明らかにすることが必要不可欠であることから、DNA barcoding、分子系統解析、交尾器形態の観察を組み合わせた Integrated Taxonomy を導入した。

第２章では、ベトナムから得られた *Phintella* 属 129 標本と、*Phintella* 属と極めて形態的に類似する *Laufeia squamata* 3 標本を解析対象とし、13 属 15 種 18 標本を外群として、Integrated Taxonomy による種の識別を行った。まず、ミトコンドリアの CO1 遺伝子、16S-ND1 遺伝子、核の 28S 遺伝子の塩基配列データセットを元に、ABGD 解析および bPTP 解析を行うことで（DNA barcoding）、20 から 43 の MOTU（molecular operational taxonomic unit）を識別した。ついで、前述の３つのデータセットを元に最尤法及びベイズ法による分子系統解析に基づき、各 MOTU の単系統性を評価した。単系統性が支持されなかった場合は、単系統群となるまで近隣の MOTU と統合した。その結果、15 から 22 の MOTU に統合された。最後に、これらの MOTU について詳細な形態比較を行った結果、22 の MOTU が交尾器の形態学的形質によっても識別できた。したがって、これら 22 の MOTU を互いに独立した種であると結論付けた。一方で、*P. aequipeiforms* Zabka, 1985 と *P. lucai* Zabka, 1985、*P. debilis* (Thorell, 1891) と *P.*

bifurcilinea (Bösenberg & Strand, 1906)、*P. suavis* (Koch, 1846) と *P. vittata* (Koch, 1846) が、それぞれ同種であることが判明した（第４章でシノニムの提案を行った）。また、雌雄の対応関係が、12 種について新たに判明し、Logunov & Jäger (2015) が示した *L. squamata* の雌雄の対応関係が誤りであったことが判明した。

第３章では、ベトナムに産する *Phintella* 属の種の系統関係を推定した。その結果、ベトナムに産する全種が明瞭な単系統群（VN クレード）を構成し、*Laufeia squamata* はその単系統群の内部に位置づけられることが分かった。また、VN クレードの内部に、以下の４つの明瞭な単系統群が認められた：*P. debilis* クレード、*P. lepidus* クレード、*P. versicolor* クレード、*P. squamata* クレード。*P. sancha* の系統的位置は安定しなかった（暫定的に独立したクレードとして扱った）。

第４章では、分子情報の取得に適した標本が得られなかった *P. accentifera* と *P. argenteola* の標本を形態学的に詳細に検討した。その結果、*P. argenteola* が *P. debilis* の新参シノニムであること、*P. accentifera* が独立の種であることが確認され、合計 23 種が識別された。そのうち 13 種は新種であった。雌雄の形態形質に基づく検索表の作成、種の記載・再記載、４例のシノニムの解決を行った。

第５章では、第４章で識別された 23 種について、採集地点の位置情報を元に、ベトナムにおける分布様式の類型化を行った。３種は「ベトナム全域分布」であった。また、それらとは別の２種も、本研究ではベトナム南部からしか発見できなかったものの、中国南部から記録があるため、「ベトナム全域分布」であると思われた。10 種は「ベトナム北部気候帯分布」であり、少なくともその一部は中国南部からも記録がある。一方、5 種は「ベトナム南部気候帯分布」、３種は「Trung Son 山系分布（北部気候帯分布と南部気候帯の移行帯に分布）」であった。インドシナ西部における本属の分布情報はほとんど得られていないが、ベトナム北部とベトナム南部で種構成が大きく変化することが示された。

ベトナムに産する *Phintella* 属の種の COI 遺伝子塩基配列データセットに基づき K2P 遺伝距離を算出したところ、種内の K2P 遺伝距離の最大値が 2.22%、種間の遺伝距離の最小値が 4.40%となり、明瞭な「種内–種間のバーコード・ギャップ」が確認できた。これらの値は、カナダのクモ類全般、およびカナダのハエトリグモ科を対象とした先行研究 (Blagoev *et al*., 2016) で示された値と非常に良く一致した。したがって、Integrated Taxonomy を適用できないような小規模な標本群に対しても、「種内–種間のバーコード・ギャップ（2〜5%）」を外挿することで、標本群の中に複数の種が存在するか否かを判断することが可能となった。

このように、本研究は、熱帯・亜熱帯地域において種の多様性が著しく高いクモ類やその他の陸上節足動物群を対象とした系統分類学的研究の「教科書的事例」である。